CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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- CANDU Maintenance Conference
- Feeder Crack Detection
- Reflection on Pickering Unit 1
- CNA Annual Seminar
- Perspective of Regulator
- CANDU Performance

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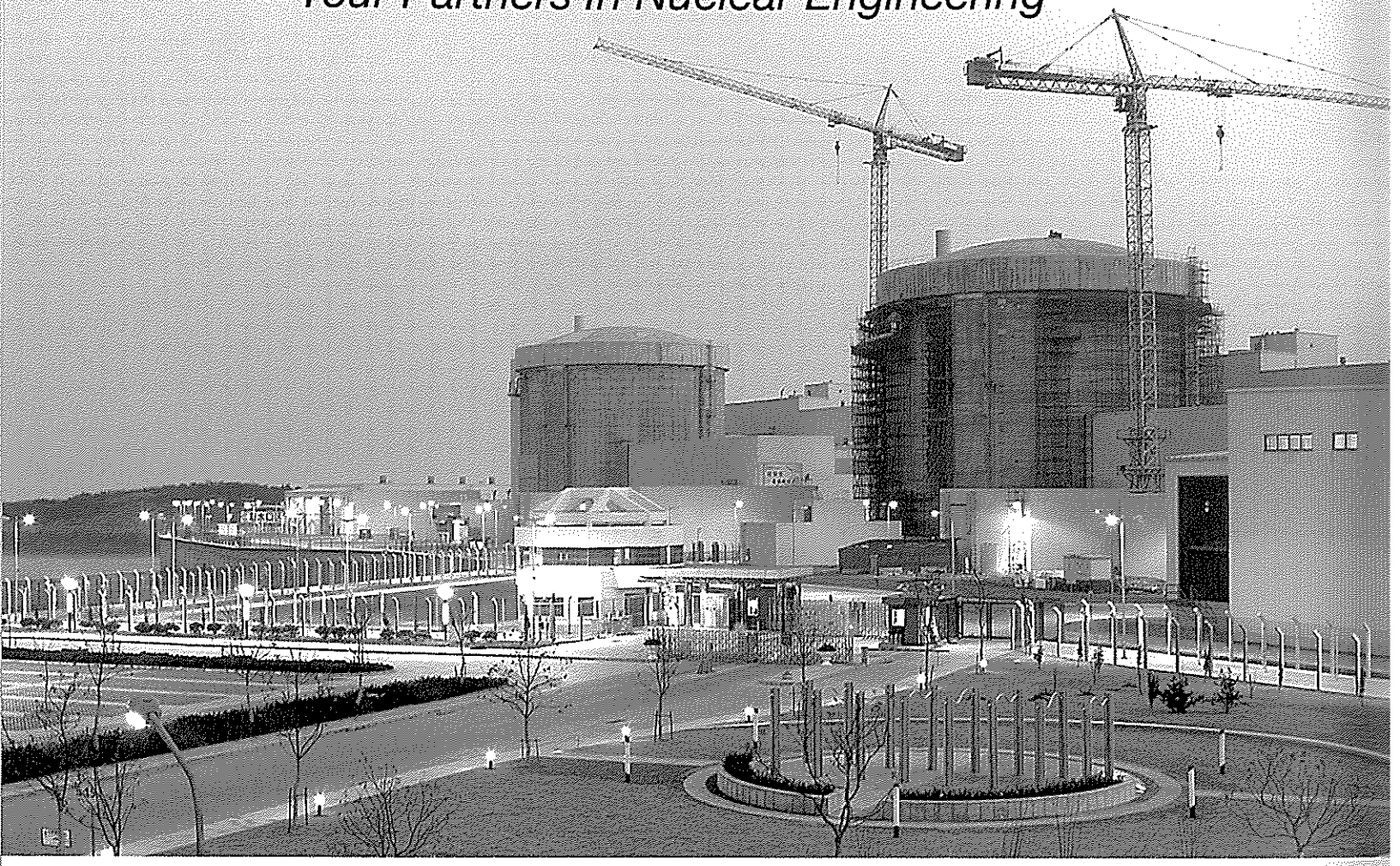

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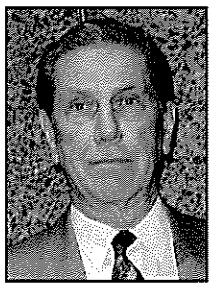
"International" safety standards?



At the CNA Annual Seminar in February, the president of the Canadian Nuclear Safety Commission stated that her organization is preparing new regulations for nuclear power plants that will be based on "international" standards that are "technology neutral". While that sounds positive and may have public appeal it could have negative consequences.

The following day senior CNSC staff formally presented the publication, "Licensing Process for New Nuclear Power Plants in Canada". Despite the use of the word "new" in the title, senior CNSC staff stated, in response to questions, that they anticipated applying the proposed new regulations to existing plants as well as to "new builds". This raises potential problems for the CANDU plants in Canada.

The "international" standards being proposed have been developed by committees of the International Atomic Energy Agency that are dominated by representatives of users of light water reactors. As such they reflect the design and characteristics of such plants. CANDU designs have a number of characteristics that are quite different from those of LWRs. The result is that some of the IAEA standards are inimical to existing CANDUs.

The Canadian regulatory requirements for nuclear power plants evolved over the years in step with the development of the CANDU designs. Early in the nuclear power program much thought was given to the question of a rational safety goal for the nuclear power plants then being considered. A "risk" objective was adopted. From an examination of industrial accidents a target of 10-5 deaths per year per reactor was initially proposed. Subsequently, this was reduced to 10-6, which is roughly the international target today.

To achieve this target a few very basic design requirements evolved, such as: the separation of operating systems, safety systems, and containment; and the requirement for two separate and independent shutdown systems to protect against potential "runaway" accidents that could threaten the containment. All of these were developed with the distinctive characteristics of the CANDU design in mind.

The CNSC approach ignores this background. Judging from early drafts, existing CANDUs may not meet the proposed regulations. This could have negative ramifications. If that situation prevails, future sales abroad of the successful CANDU 6 could be jeopardized because government policy requires exported reactors to be licensable in Canada.

Further, if the proposed new rules are applied to existing plants it could lead to serious problems for the CANDU reactors in Canada. Not only would such new standards impose unnecessary problems for the operators of existing plants they could also lead to a public relations nightmare if the "non-conformance" is misinterpreted.

Let us hope that the CNSC proceeds cautiously in its desire to adopt "international" standards.

Fred Boyd

From The Publisher

Writing as the "publisher" (self-appointed), or, more correctly, the representative of the publisher, which is, of course, the CNS, I wish to point out our new appearance, which I hope you will like.

We had a trial run of full colour in the last (December 2005) issue and that is now being fully applied. There is also a new cover design. That is not fixed and we may experiment with further variations. If any of you reading this feel you have artistic talents, we would welcome your suggestions. (Perhaps we should have a contest.)

Hopefully, you have noticed the increased number of advertisements. We welcome these, both because we feel they add to the attraction and interest of the Bulletin and because it reflects a more optimistic attitude among those companies involved in the Canadian nuclear program. And, despite our very modest advertising rates, the income helps us improve the appearance of the Bulletin.

Although I propose to withdraw from my role(s) with the Bulletin at the end of this year, I have suggested that the frequency of publication increase to six per year. The increased activity in the Canadian nuclear community justifies that and, as the only publication of its kind in Canada, I believe the Bulletin should respond.

Fred Boyd

Contents

~ Cover Photo ~

The cover photograph is a view of the Bruce A station where the major refurbishment of Units 1 and 2 is underway. This picture was taken several years ago, before the towers of the Bruce Heavy Water Plant, seen in the background, were dismantled.

– Photograph courtesy of Atomic Energy of Canada Limited

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Re: Editorial – Future of CANDU (December 2005 issue)

AECL and OPG need to confer

Your editorial in the December issue caught my interest. While you mention a number of points relative to the Future of CANDU, I thought this subject has not received the detailed assessment by CNS that it deserves.

First as you mention, - the very early decisions by senior AECL and OH management to go for natural uranium and a concept that could be built in Canada were fundamental to the subsequent operating complexity of the CANDU. These decisions led to heavy water coolant and moderator, the pressure tube concept, on-power fuelling, two shutdown systems, and the subsequent atmosphere, control and maintenance issues.

I have no doubt that the CANDU is more complex for the operators than a PWR; (even the AECL 6, which evolved from Pickering A designs from studies sponsored by OH, and improved as each new plant was committed). I believe this "operator complexity" was accepted by the originators with the expectations that the fuelling cost and plant capacity factor with on-power natural uranium fuelling would offset this additional complexity for the operators. It is not true that the operators were ignored (never spoken to); Lorne Mc Connell, Larry Woodhead and many other senior staff from Operations were with us all the way.

The PWR design people went the opposite way. They proposed a plant that had high fuel enrichment (cost), and subsequently found ways to operate for long periods with no physical core attention; and then shutdown and bring in outside trained expert crews for refuelling, repairs, and periodic maintenance. They have been quite successful in making these shutdowns relatively short and quite practical to a utility that has annual periods of low demand.

I don't know, off hand, how the CANDU is stacking up with regard to fuelling cost and overall power cost compared to the PWR, but the plant capacity factor and heavy water management, as well as operating complexity, probably make the best CANDUs less attractive for some operating companies. This comparison needs expert attention now.

The AECL shift to the ACR with its modest enrichment, ordinary water cooling and a very tight core, still leaves me wondering about the complexity; but certainly has potential economics in it's favour. There needs to be a serious session between the AECL and OPG operating experts to assess the potential and the problems involved.

Why doesn't CNS sponsor such a get together? The Canadian " CANDU" concept may be at stake in 2006.

W. G. Morison

Bill Morison is a former vice-president of engineering at Ontario Hydro. He was awarded the W. B. Lewis Medal in 1978 for his contributions to the design of the Pickering and Bruce units.

In This Issue

The technical focus of this issue comes from the **7th CNS International CANDU Maintenance Conference** of last November. As our report tries to convey, there is a deep appreciation of the importance of maintaining the fleet of CANDU units and a strong interest in sharing experience.

Augmenting the concise report there are four papers, selected with some difficulty, which give some insight into the breadth and depth of topics discussed. First is one on the central problem of feeders, **Crack Detection Tools for Feeder Inspection.** Then there is a perspective from the project management viewpoint, **Pickering Unit 1 Return to Service.** Another topic is addressed in, **Wall Thinning of CANDU Large Bore HTS Piping.** Then, turning to the balance of plant, there is a paper on, **Steam Generator Tubesheet Waterlancing at Bruce B.**

Then we turn to the broader view with our extensive report on the **CNA Nuclear Industry Seminar 2006** held in February and, possibly the most significant presentation, that by our chief regulator, entitled, **Planning for Canada's Expanding Nuclear Program.**

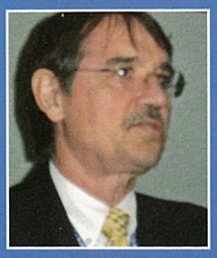
There is a relatively short set of items in our **General News** section, followed by four **Obituaries,** reflecting our ageing community.

Then we offer a few diverse pieces: a commentary titled, **CANDU is not an Edsel but could be an AVRO Arrow;** another bit of history in **History of the name Canatom;** and a concise summary of the generally good performance of CANDU units in Canada and around the world, **CANDU reactor performance 2005.**

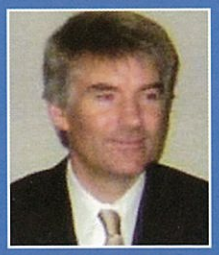
The section on **CNS News** provides some insight into the many activities of the Society. That is followed by a **Book Review,** the always interesting perspective of **Endpoint,** and an updated **Calendar.**

We hope you find something of interest in this collection and invite your comments.

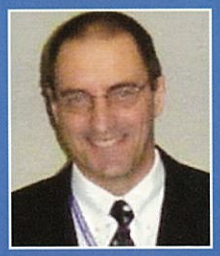
Brent Murchie



John Coleby



Mark Elliott



Ken Ellis

Bill Piklington

Guest Speaker
Warren Macdonald

7th CNS International Conference on CANDU Maintenance

Attendance at Conference Reflects Importance of Maintenance

Theme: Maintain the Fleet – Maximize Performance

Reflecting the importance of maintenance of the current fleet of CANDU units, a record of more than 350 delegates attended the **7th CNS International Conference on CANDU Maintenance,** held in Toronto, Ontario, November 20 to 22, 2005. The numbers were a pleasant surprise for the organizers even though they put pressure on the resources of the hotel.

Following the format of the successful previous maintenance conferences, the gathering began with a reception on the Sunday evening. The technical sessions began on the Monday morning and ran through to mid afternoon on the Tuesday.

Augmenting the presentations was an exhibition by a score of companies offering products and services to aid maintainers of CANDU plants in Canada and abroad. The opening reception on the Sunday evening and the one preceding the conference dinner on the Monday evening were held in the exhibition area, giving delegates a relaxed opportunity to observe the many products and services offered

The guest speaker at the dinner was **Warren Macdonald**, an Australian adventurer who lost both of his legs in a mountain climbing accident. He gave an inspiring talk on how he was able to overcame that tragedy and go on to climb Mount Kilimanjaro using special artificial prostheses.

There were also speakers at the two luncheons. At the Monday lunch Cmdr. **Marcel Hallé**, of the Royal Canadian Navy spoke about Canada's submarines, using a slight variation of the conference theme - *"Maintain the Fleet - Maximize Operation"*. Submariners have a number of challenges and goals in common with nuclear plant operators, he remarked, especially the need for the correct maintenance. He went on to give a fairly detailed account of the operation of Canada's four submarine fleet.

CNS past-president **Bill Schneider,** recently retired from Babcock & Wilcox Canada, was the speaker at the Tuesday lunch. He offered his views on the causes of the decrease in capacity factor of Canadian nuclear plants, citing degradation and extended outages among other factors. Then, in closing, he spent a few minutes outlining some of the upcoming CNS activities, such as the Workshop on Engineering Structural Integrity (3,4, April 2006) and the Steam Generator Conference (26-29 November 2006).

The conference began with a short plenary session on the Monday morning. **Brent Murchie,** conference chair, welcomed delegates, especially those from overseas, and noted that the CNS maintenance conferences were now being planned on a two-year schedule rather than the three-year period formerly. He then introduced honorary chair, **John Coleby,** vice-president, Pickering A, Ontario Power Generation.

Rather than just chair the session, Coleby gave a full presentation. He began by endorsing the theme chosen for the conference: *Maintain the Fleet - Maximize Performance.* Coleby said there were four key messages he wanted to leave:

- achieving a reliable plant;
- Pickering A advantages;
- Pickering A report card;
- process efficiency.

A reliable plant must be the primary focus, he asserted. That requires a safety culture and a focus on results. Employee morale is important, he added.

Pickering A has the advantage of involving the future operators, he said. The infrastructure will be set up before plants are restarted.

Pickering A units are operating well with staff and management engagement. There is a low backlog of required work, he stated.

On process management he noted that there had been considerable improvement since the 1990s when there was a lack of process and poor configuration management. Almost as an aside he commented that the US team brought in did force the then Ontario Hydro nuclear group to look out to the world.

After expanding on these topics he offered some "lessons" learned. CANDU has too many moving parts, he said, making it difficult to maintain. There had also been problems with configuration management and life cycle management. He commented that if the CANDU design is not improved the next Canadian nuclear plant would likely be a PWR.

Mark Elliott, director of station engineering, Pickering B, OPG, noted the decline of performance of his station beginning in the 1990s and continuing into this decade. There was a long list of problems, he said, but many are now corrected and a number of safety improvements have been made. There is, however, still a high rate of forced outages. The target is to achieve 85% capacity factor and less than 5% forced outage rate by 2007. Beyond that date, he said, the station staff hoped to achieve 90% capacity factor and outages of less than 40 days.

Continuing the theme, **Ken Ellis,** vice-president maintenance at Bruce Power, introduced the phrase, "exotic technology leads to exotic problems". As an illustration he showed photographs of operators being suited up for inspection of the vacuum building. He added the phrase "need to do right maintenance and do maintenance right". There are "event-free" tools, he said, such as: pre-job briefings; adherence to procedures; three-way communication; conservative decision-making. Maintenance staff need to understand and have better interaction with operators, he said in closing.

Bill Pilkington, former manager and site director at the Point Lepreau station in New Brunswick, now in NB Power's corporate office, was the final plenary speaker. He provided some background leading up to the decision a few months previously by the New Brunswick government to approve the refurbishment of the Point Lepreau station. Much planning had been done, he noted. Atomic Energy of Canada Limited was chosen to do the bulk of the work. Two major contracts were awarded to AECL, one for retubing , the other for general refurbishment. NB Power will have a relatively small oversight team. The plan calls for the plant to be shutdown in 2008 and restarted in 2009.

Over the balance of the two days, more than 60 technical papers were presented, in four parallel sessions. The titles of the sessions give an insight to the scope of the papers presented: Management; Environmental Qualification; Feeders; Feeder Inspection; Fuel Channel Condition Monitoring; Fuel Channel Inspection Chemistry; Electrical Equipment; Steam Generator Tube Inspection; Steam Generator Cleaning; Plant Life Management; Heat Transport System; Processes; Preventative Maintenance; Containment; Reliability; Dose Reduction; Project Management. All were well attended but some topics, such as "Plant Life Management" and "Fuel Channel Inspection", were standing room only. (*Four papers are reprinted in this issue of the* CNS Bulletin.) A CD with most of the full papers is available from the CNS office.

This was a very well organized and run meeting. Ample time was allotted for presentations and questions and the extended coffee breaks allowed attendees to share their experiences in a casual setting. With the opening reception, conference dinner, two lunches, continental breakfasts, and coffee breaks, the meeting provided real value.

The organizing committee was chaired by Brent Murchie, of Bruce Power. Peter Gowthorpe, of INTECH International served as administrative chair. The technical program was organized by: Marc Paiment; Bob Tapping Colette Taylor; Greg Shikaze; and Jeff Millman. Other members of the committee were: Ken Belfall; Mike Schneider; Heather Smith; Pam Sprague; Ben Rouben; Denise Rouben; Tim McLaughlin; Ed Price; Michael Lees; Jacques Plourde; Eric Williams; Malcolm Lightfoot; Marc Provencher; Janice Keating; Bill Schneider.

Sponsors were: Acuren; AECL; Babcock & Wilcox Canada; Black & McDonald; Bruce Power; GE Energy; Hydro QuÈbec; INTECH International; New Brunswick Power; Nuclear Logistics Inc.; Ontario Power Generation; SNC Lavalin Nuclear; Zetec.

Exhibit and Reception

Crack Detection Tools For Feeder Inspection

Eric Lavoie, Éric Lavallée[1], and Gilles Rousseau, Jean-François Coté[2]

Ed. Note: The following paper was originally presented at the 7th International Conference on CANDU Maintenance, *Toronto, Ontario, 20-22 November 2005*

ABSTRACT

Since 1998, the Hydro Québec Research Centre (IREQ), in collaboration with Gentilly-2 (G2), has been working on the development of inspection devices for the feeder tubes of CANDU power plants. After the 14-probe METAR, which is now the standard equipment for thickness measurement of CANDU feeder pipes, IREQ addressed the industry's growing problem of crack detection in feeder bends and in welded areas. This paper presents three tools developed for this purpose: the Cracking Crawler for crack detection in bends, the Orbital bracelet for crack detection in pipe-to-pipe welds and the Grayloc Scanner for crack detection in the grayloc welds. In addition to the robotic development, the ultrasonic (U-T) techniques developed for automated feeder weld inspection will be described. An earlier version of some of these tools was presented at the 6 th International Conference on CANDU Maintenance in 2003, while detailed herein is the latest development and the results of their first field trials, up to the licensing and technical transfer.

1. Introduction

Since 1998, the Hydro Québec Research Centre (IREQ), in collaboration with Gentilly-2 (G2), has been working on the development of inspection devices for the feeder tubes of CANDU power plants. After designing the 14-probe METAR, which is now the standard equipment for thickness measurement of CANDU feeder pipes, and the Motorized Métar, IREQ, assisted by G2 inspection personnel, addressed the industry's growing problem of crack detection in feeder bends and in welded areas. Work on a crack inspection device started at IREQ under Hydro-Québec funding in 2002. Following an agreement with IREQ in 2004, the CANDU Owner Group (COG) acquired the intellectual property right from HQ in order to develop crack inspection tools suitable for the entire industry and to be able to supply these tools at a lower price. Both Métar were transferred to and are being commercialized by RD Tech Inc., which was bought by Zetec Inc in June 2004, as should be the Bend Cracking Crawler later this year.

2. Cracking Crawler

The Cracking Crawler was developed by Hydro-Québec following the appearance of cracks at the PLGS (Pointe Lepreau Generating Station) plant. Its first application was during an unplanned outage in the spring of 2003 when it was validated. It was subsequently employed during a full inspection program that fall at G2. At that time, only the first bends needed to be inspected so space constraints were much less of an issue. This crawler was presented during the CNS 6th international conference on CANDU maintenance in November 2003 [2]. Following the discovery of cracks in some second bends at PLGS (fall 2003), the crawler was modified to be able to reach

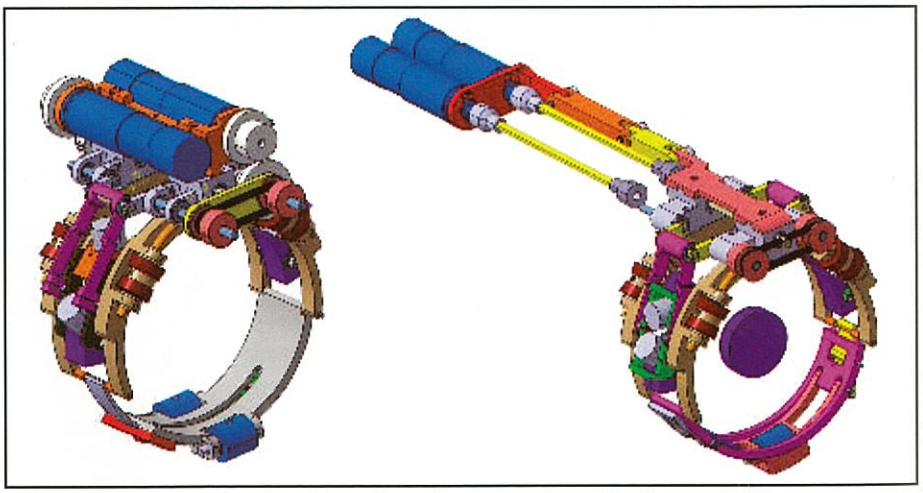


Figure 1: Cracking Crawlers; versions 2003 and 2004.

and inspect these areas as well. For this purpose, the motors initially fixed on top of the frame were moved behind it onto a flexible shaft assembly, thus reducing the overall height and bulk of the crawler. This second generation bend crack inspection tool was used during the PLGS spring 2004 outage for a complete second bend inspection

1 Institut de recherche d'Hydro-Québec, Varennes (Québec)

2 Hydro-Québec, Centrale nucléaire Gentilly-2, Gentilly (Québec)

program. Another feature of this new tool is that the probe holders are reorganized to scan both the intrados and the extrados in a single pass, according to a newly revised v18 procedure for crawler inspection. Lastly, because the area to be inspected is out of reach and sometimes out of sight, the water-based couplant is now fed directly through the wedges, so as to eliminate the need to manually apply it before the scan. Following the success of the spring 2004 inspection, the crawler was again modified to make it even easier to use, calibrate and maintain. This latest version of the tool will be discussed in this paper.

2.1. Crawler Description

The 2005 Cracking Crawler consists of three principal assemblies: the Scanning Assembly (SA), the Frame assembly (F) and the Motor Assembly (MA), as shown in Figure 2 below.

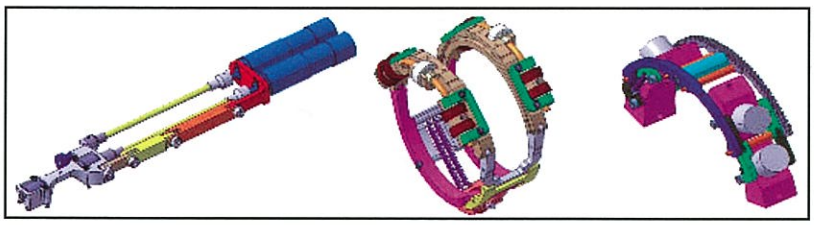


Figure 2: Motor Assembly; Frame Assembly; Scan Assembly.

The Motor Assembly, which is the same for all sized crawlers, is composed of the motors, the flexible driving shaft and the gear box, which leads to the driving wheel and is responsible for the oscillating motion. The Frame assembly and the Scan Assembly are different for each size of crawler, however the components remain very similar, and when possible, identical parts are used. The Frame assembly consists of solid rings which can be attached to the feeder and contain the driving wheels and the closing mechanism. The Scan Assembly is the moving part of the bracelet and it includes all the U-T probes, probe holders, wires and tubing (not shown).

As mentioned above, the 2005 generation cracking crawlers are completely revised, designed not only for industrialisation, but also to lighten the inspection workload by making calibration and maintenance easier. This crawler has less moving parts, a new rack and pinion swing assembly and a fixed distance between the probes at all times. Scribe lines were also added to the frame and swing assembly to facilitate field calibration. Finally, the closing mechanism was improved to make it easier to handle during blind installation.

Along with these mechanical modifications, the entire inspection system, including computer display, procedure, and technique was revised to facilitate inspection and analysis and to guarantee better flaw detection. A couplant-monitoring channel was added in the inspection windows to assure good contact between the wedges and the feeder and to optimize scan quality. The complete inspection technique was modified to reduce the number of false indications caused by couplant build-up, among other things.

Figure 3 shows the cross section of the crawler, revealing the probe and probe holder position. Note that probes 1 and 3 face upwards towards the extrados, while probes 2 and 4 face downwards towards the intrados. With this new configuration, adopted in 2004, both the intrados and the extrados can be inspected in a single scan. Nevertheless, a flaw should still be detected by at least two probes, as required by the procedure given in [5]. Probes have a circumferential raster movement of approximately 15 degrees, which corresponds to a linear displacement of nearly 25mm for the 2.5in crawler and nearly 17mm for the 2.0in crawler.

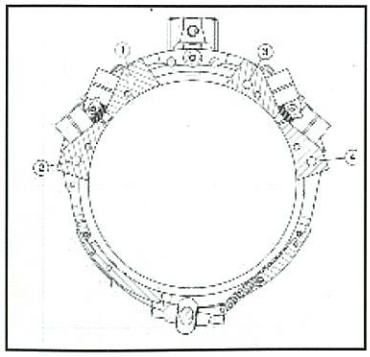


Figure 3: Probe Position.

Prior to being used in the field during the G2 and PLGS spring outages, the new crawler was fully qualified and tested. A team, with this sole goal, spent time at both Gentilly (QC) and Point Lepreau (NB) during the fall of 2004 and the winter of 2005 in order to get the tool ready. The new inspection procedure was developed, field operators were trained, and a full qualification program with peer review was executed. After its success during the spring outages, the tool is now being transferred to Zetec and it is COG's intent to have the utilities (utilities???) perform the next crawler inspection with an industrialized version of the tool.

Following the detection of a leak in the now infamous G09 feeder during the summer of 2003, Hydro-Québec's IREQ rapidly designed a new crack detection tool for circumferential cracks called the Orbital Bracelet or Orbital Crawler [2]. This tool is aimed at inspecting in-field feeder welds, more specifically, those located at the limit between the lower and upper feeder cabinets, at the freeze can level. Again, it is an in-situ inspection device (as was the cracking crawler and other Métar tools before it), but space constraints in this area are less of an issue. However, for the 2005 G2 outage, a device was needed to inspect other field welds located just after the first bends, where

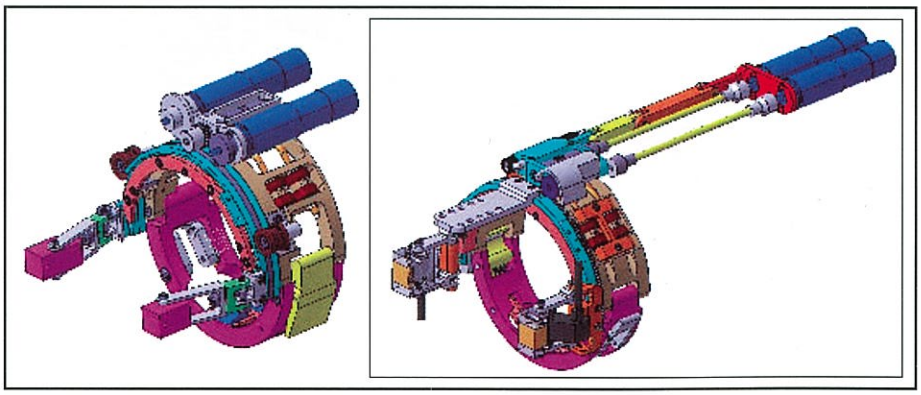


Figure 4: 2003 and 2005 Orbital Scanners.

Figure 5: Pipe to Pipe Scanner on a vertical feeder.

space constraints are similar to those imposed on the cracking crawler. Hence, the next generation of orbital crawler was created, often referred to as the Pipe to Pipe Crawler.

The new version of the scanner is very similar to the previous one, with the biggest improvements being the relocation of the motors to behind the tool to minimize space requirements, the reduction of the number of components to facilitate maintenance and the replacement of the UT probes with Phased Array probes for inspection purposes. This new version also uses the same motor assembly as the Bend Cracking Crawler.

The new pipe to pipe scanner was successfully employed during the spring 2005 G2 outage. Though no cracks were found, the scanner proved to be easy to install even after the second bend and space constraints beyond the bends were not too much of an issue. The inspection technique, involving Phased Array probes, will be discussed later in this paper.

4. Grayloc Scanner

Following the cracking incident of the G09 feeder, the CCSN requested G2 to closely monitor all their field-welded joints. Among these joints are the Graylock welded joints, situated

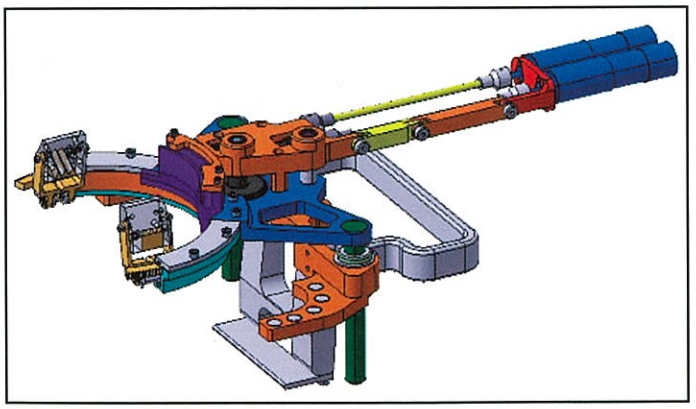


Figure 6: Graylock Scanner.

between the pressure tubes and the feeders. Due to their shape and position, these joints can not be inspected with the other methods, so a new tool was developed; the Graylock Scanner.

Based on a similar working principle as the Orbital Crawler (i.e. Two PA probes rotating 180 degrees to cover the entire circumference), the Graylock Scanner differentiates itself by being fixed directly on the Graylock hub and not on the feeder like the other tools. Using a series of magnets as a holding mechanism, the base of the scanner is positioned according to the Graylock hub screws and designed to be installed without removing the tire wires or the plates, eliminating the need for tools. Axial displacement perpendicular to the hub permits good probe positioning while circumferential movement permits scanning very close to the weld, even in the intrados were constraints due to feeder position and shape can make it difficult. The tool can be placed on either face of the hub depending on access.

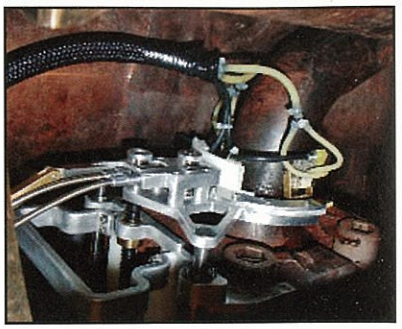


Figure 6: Graylock Scanner in-situ on a hub.

After being extensively tested and tried during the winter of 2005 prior to the G2 spring outage, a procedure for using the tool and the new inspection technique were written [3].

5. Contact Phased-Array Technique for Feeder Welds

The following section will give a detailed explanation of the Phased Array (PA) inspection technique used on both the Orbital and the Graylock Scanners.

After the discovery of an Intergranular Stress Corrosion Cracking (IGSCC) in a field weld at Gentilly-2 in 2003, the recommendation was that full penetration weld-repaired areas of accessible feeder welds be inspected. The grayloc welds are the most accessible welds and an inspection campaign was prepared to assess the condition of these welds. The objective of the inspection method is to find a 1 mm deep by 10 mm long circumferentially oriented EDM notch in the weld volume and the pipe side Heat Affected Zone (HAZ). This detection capability was demonstrated on machined samples and on grayloc weld mock-ups.

A contact phased-array ultrasonic (UT) examination method was developed for the detection of circumferential flaws in CANDU PHT system grayloc hub welds. The component is a flange adaptor to pipe weldment. The weld is full penetration with a J-preparation. Pipe thickness is 5.4mm (2.0" NPS) or 7.0mm (2.5" NPS). The ID weld root reinforcement is ground flush. The OD weld cap is ground flush on a CANDU-6, but the technique was demonstrated successfully in as-welded condition.

This technique provides a full volumetric weld inspection for circumferentially oriented flaws, 360∞ around the weld circumference, by performing multiple line-scans from the pipe side over the entire circumference. The inspection may be done with the motorized grayloc scanner using two PA probes to cover the entire volume, or manually using specially designed alignment jigs and multi-pass inspections.

The phased-array transducer used for detection is 5 MHz, 12 elements, 0.6 mm pitch by 7.2 mm wide with a low housing and a side-exit cable. The active surface element is 7.2 mm wide by 7.2 mm long. The wedge is made of rexolite with a nominal

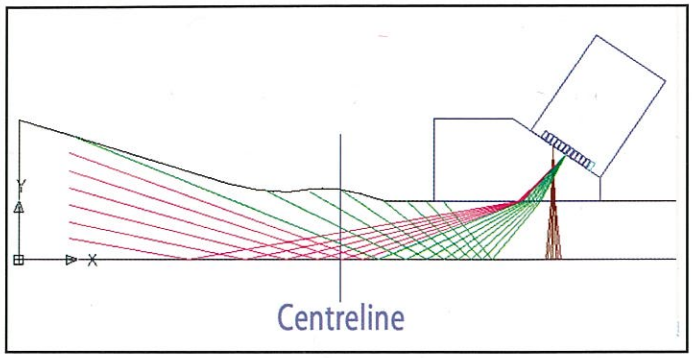


Figure 7: Pipe-hub cross-sectional view with superimposed ray-tracing of the three phased-array set of focal laws for a 2.5 in grayloc hub weld. Ray-tracing shows the probe at 4mm away from the weld cap edge and rays are equally spaced by 5 degrees.

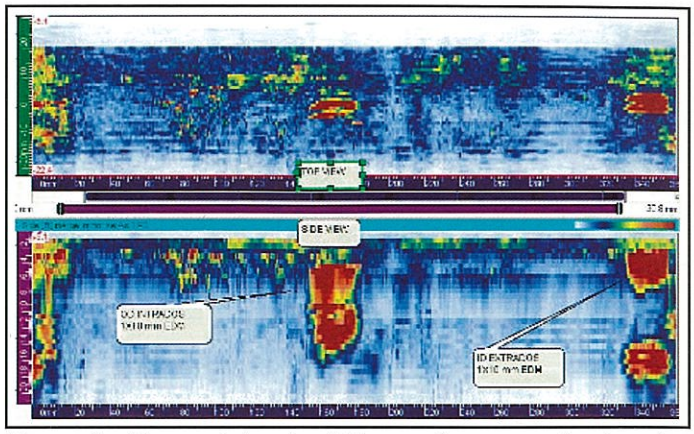


Figure 8: Merge data of a 2.5in mock-up sample showing the two 1X10 ID and OD EDM notches located in the weld centerline.

angle of 34.0 degrees. The detection wedge is 20 mm long and uses a special damping compound to absorb all internal reflections from the tip of the wedge. A mixture of exosen and water is used as couplant and is fed through the wedge.

If ID flaw characterization is needed, 10 MHz, 16 elements, 0.45mm pitch by 7.2 mm wide with a low housing and a side-exit cable may be used. The active surface element is 7.2 mm wide by 7.2 mm long. This high frequency probe is recommended for back-scattered tip-echo diffraction, if the need arises to characterize an indication.

The phased-array unit is an Omniscan© remotely controlled via Tomoview©. The instrument is able to connect two 12-element phased-array transducers and to create the three sets of focal laws required by each probe: straight beam, 40-70 degree shear wave in two degree increments, and 70-80 degree shear wave in one degree increments (see Figure 7). The instrument has automatic calibration of focal law groups using an ID and OD notch, calibration storage, Time Corrected Gain (TCG), data recording, data playback, and was qualified successfully on representative mock-up samples.

The analysis software used is Tomoview©. It is capable of merging all angle beam data or a selection of such data, and of processing it to create one volumetric image with Top and Side views (see Figure 8). The volumetric views form the primary display used for flaw detection. Once an indication has been located, other views are used to extract additional information to aid in the assessment of the reflector. Additional views are Sector scan (S-scan), C-scan and A - scan. An ID indication will usually be observed on the 70-80 Shear wave channel while OD indications are seen only on the 40-70 Shear wave channel.

The weld, as well as the HAZ on the pipe side, is inspected with the sensitivity specified in the CSA N285.4 (Figure xxx). Due to the limitations imposed by its geometry, the HAZ on the hub side is inaccessible. However, because of the high refracted shear wave angle possible with phased-array, part of the internal diameter HAZ on the hub side is covered by the 70-80 degree angles when the transducer is closest to the weld. The OD of the grayloc hub side is not covered at all because the backwall reflected shear wave propagates mostly parallel to the OD surface which is an unfavourable condition for shear wave propagation or corner reflection.

The weld root is normally ground flush so no interface echo is expected. However, Flow Assisted Corrosion (FAC) could lead to false indication from the root. It is expected that in some cases, the root geometry may cause non-relevant indications accompanied by mode-conversion signals. Any dispositional indication will have to be evaluated by radiography (ID connected) or Liquid Penetrant (OD connected). A tip-echo diffraction technique is also recommended, using 10 MHz transducers, and can be applied on a ground weld cap only.

The phased-array inspection method was developed and tested on a nominal feeder pipe and on thinned cross-section samples, representative of removed feeders. The wall thickness is measured and used during analysis. The procedure applies to the entire thickness range allowed by the code (up to 40% reduction from nominal).

6. 2005 Outage and Subsequent Work

In prevision of the G2 and PLGS outages, the bend cracking crawler, the orbital crawler and the Grayloc were fully tested and tried during the fall of 2004 and the winter of 2005. Inspection staff was trained on the new tools and the new inspection techniques and procedures were written. Though only the cracking crawler went through the entire certification process with peer review evaluation, all were qualified to assure consistency in the inspection.

During the outage, the tools performed as expected as no major problems were encountered. Though the scope of the inspection at G2 was rather large, especially with three prototype tools, the schedule was met and even with some time to spare.

Now considered mature enough to be industrialized, the Bend Cracking Crawler is in the process of being transferred to Zetec Inc. for commercialisation and it is already planned that both G2 and PLGS will use the newest version for their next scheduled inspection in the spring of 2006. The other tools, the orbital crawler and the scanner, will remain as prototypes for at least one more generation to enhance their capabilities. The Grayloc scanner should be used again next year at G2, while the Orbital

Table 1: Outage Application of IREQ's Feeder Inspection Tools

Feeder Inspection Program		
	G2	PLGS 2nd elbow only
	Visited sites	Visited sites
Bend Cracking	136	~100
Pipe to Pipe Welds (G2 only)	111	
Grayloc Welds (G2 only)	135	

crawler may have to wait until 2007, unless there is an earlier demand in the industry. All of these tools could be modified to adapt to various specific CANDU applications.

7. Conclusion

Working together since 1998 to develop feeder Inspection tools, Gentilly-2 inspection personnel and IREQ researchers have conceived and developed many innovative inspection devices. These devices are aimed at reducing human radiation exposure while improving the quality of the feeder inspection results. Although the responsibility of funding the projects was transferred to COG in 2004, the team remains the same, developing new tools at an impressive rate. The three tools presented in this paper were all used during the most recent outages, both at G2 and some at PLGS, with good results. They are also expected to be used again in the next outages, either as commercialized versions or still as prototypes. Plans are now to spread the use of these tools to all the CANDU facilities that could profit from their capacities.

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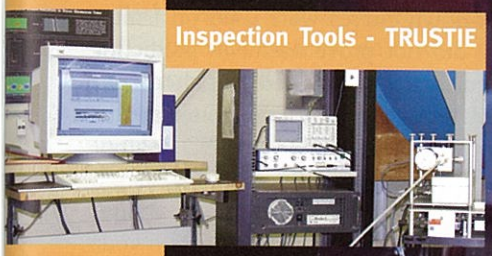
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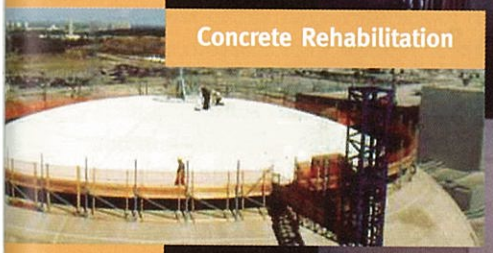
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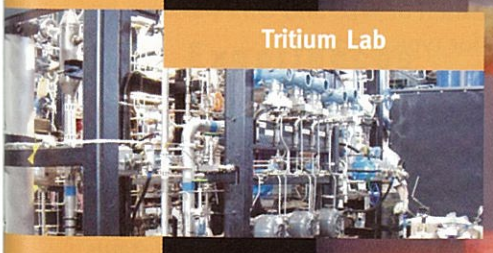
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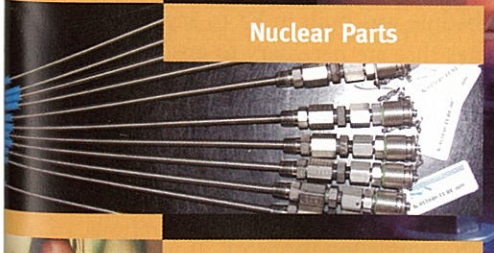
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Pickering Unit 1 Return To Service

– Experiences in Managing a $1billion Project

by Chris Pattison[1]

Ed. Note: the following paper was presented at the 7th CNS International Conference on CANDU Maintenance *held in Toronto, Ontario, 20 22 November 2005.*

ABSTRACT

Traditionally, Ontario Power Generation - Nuclear (OPG-N) has used task work-down curves to measure performance against plan. This approach was used on the Pickering Unit 4 Return to Service project and did not prove useful in predicting the schedule slippage that occurred. For the Pickering Unit 1 Return to Service (RTS) project, the decision was made to use earned value reporting and analysis to enhance the existing performance reporting.

The Unit 1 RTS project was broken down into fourteen sub projects along equipment or physical plant areas and five major work group areas. This formed the basis of weekly reporting for both schedule and cost performance index (SPI and CPI).

The earned value reporting provided a number of benefits over the existing performance reporting methods. SPI provided an early predictor of potential schedule slippage and initiated management corrective actions long before critical path analysis indicated any potential problems. Both SPI and CPI provided better indicators of project performance than seen by task work-down curves and were the basis for consistent reporting to executive level management. Earned value reporting was extended into more non-traditional areas and the design engineering work program was developed and reported using SPI and CPI.

As can be expected on projects of this nature, where equipment has laid dormant for a number of years, there was some scope growth that necessitated adjustment of the original baseline schedule. A decision was made and a methodology developed to renormalize the Unit 1 RTS schedule after the scope growth reached 5% (after six months of work). Renormalization allows the additional scope to be added to the schedule without losing the project performance history.

The overall use of earned value analysis and reporting resulted in improved understanding of project status, initiated early corrective actions where necessary and provided a consistent reporting format for executive overview. This approach is also applicable to Unit planned outages.

1 Ontario Power Generation

1.0 Background

Return to service projects are larger and much more complex than nuclear unit outage, for example the number of design changes undertaken (850), activities in the P3 schedule (29,000), P3 task relationships (61,000) and the total number of trades hours expended (2 million). For the Unit 1 Return to Service project, the decision was made to use earned value reporting and analysis to enhance the existing performance reporting. This paper describes the approach used, reports produced and lessons learned.

OPG-N has traditionally used task work-down curves to monitor outage performance against plan; while this provides some indication of performance, it can also mask problems for some time as 'low hanging fruit' can be completed earlier than planned providing a false indication of progress. Task work-down curves were used on Unit 4 Return to Service (RTS) and they did not prove useful in predicting the schedule slippage that occurred. It was recognized that alternative approaches would be required for Unit 1 RTS in order to better predict potential problem areas.

2.0 Methodology

2.1 Work Breakdown Structure

On a project of this size and complexity it is necessary to break down the data into areas that assist understanding of project status and identify performance in areas critical to project success. The work breakdown structure (WBS) for the Unit 1 project broke down the work into fourteen system/physical plant (sub project) areas. An organizational breakdown structure (OBS) broke the work along major contractor and OPG workgroups; the combination of WBS and OBS was used for weekly reporting. See *Appendix A* for typical report.

2.2 Primavera P3 Schedule

Tasks were planned at a detail level in the PassPort work management system, in a similar way to task planning across OPG-N. These tasks were uploaded daily into P3 and, as task status progressed, status was also uploaded daily into the P3 schedule so that detailed project status was maintained. A hierarchical schedule was built in P3 to accommodate the detailed field status updates that are necessary to ensure that trades are working in the correct sequence and also to provide a higher level of reporting for management analysis and action. The P3 schedule is updated daily with a new weekly P3 schedule published for both trades work direction and also for project reporting.

Detailed task estimates for construction trades were provided by the contractors who were assigned with completing the work. It was necessary to make adjustments to some individual task resource loading to ensure that overall project critical path was not allowed to extend.

Several iterations of task loading and work sequencing were necessary to ensure that critical path was maintained and staffing levels optimized.

2.3 Earned Value Analysis and Reporting

It was decided at an early stage that earned value reporting would be in hours rather than $'s as the majority of OPG and Contractor staff involved had a good understanding of the hours associated with a work program or task. Separate weekly financial reports were issued to report on the project cost status.

Earned value reports were produced weekly at the sub project and OBS level. Data sources for the earned value reports were:

- Weekly issued P3 schedule for earned hours.
- Baseline P3 schedule for the planned hours.

Weekly timekeeping systems for actual hours worked (TEMPUS for the OPG hours and Wizard for the contractor hours).

Wizard is a PC-based time reporting system that was in use by one of the major contractors that provides commodity-based tracking of tasks. Use of Wizard was expanded to all contractors and an interface built to the OPG cost reporting system.

Both TEMPUS and Wizard are batch updated weekly into OPG financial systems and, after review, the weekly project hours are posted.

Complete earned value (Cost and Schedule Performance Indices, CPI and SPI) reports were produced within three working days of the weekly P3 schedule issue. The earned value reports are typically graphical (S curve) or tabular and are shown in *Appendices A & B.*

Because of the large volumes of data being generated weekly and the different data sources, it was necessary to automate as much of the data transfer as possible, this has been effected with Access databases and Excel spreadsheets. One side effect of the automation is the need to develop analytical techniques to spot errors in automated batch updates such as replication of a week's data rather than a new week refresh or data transposed by one line due to an unexpected update or manual intervention.

3.0 Experiences

The SPI indicators provided a much earlier indication of potential schedule slippage than either critical path analysis or task work-down curves and allowed management to take early action to correct a poor trend and recover some of the schedule slippage. See *Appendix D* for a comparison of predicted schedule slippage from both SPI and critical path analyses.

The Unit 1 RTS project was subject to independent oversight and audit. There were some initial teething problems between the internal weekly reports and the external monthly reports that were associated with both a month end fiscal period and also TEMPUS and Wizard reports. Both issues were resolved within the first three months after mobilization and there has been consistent reporting subsequently.

After some four months of performance reporting, it was recognized that there were some areas of the project that were not progressing according to plan and a re-estimate was required. A number of alternative approaches were made to estimate the remaining project requirements including a formulaic analysis based on SPI and CPI performance to date projected onto the remaining project scope. This formulaic analysis proved a useful validation of independent estimating techniques and highlighted some significant differences for further analysis.

On a project of this nature where equipment has laid dormant for several years, it is not unusual to expect some discovery work; this has amounted to a 10% scope increase over the life of the project. After about 6 months the project scope increase was 5% and was starting to have an affect on the earned value reporting. It was decided that the scope increase needed to be incorporated into the earned value reporting and the baseline was renormalized. This is a different approach than rebaselining, which has the effect of losing project historical schedule performance.

To effect the renormalization, the following steps were taken:

All historical baseline plan data to the renormalization date remained unchanged. All tasks that existed in the original baseline schedule retained their schedule dates. All new tasks were added with the current schedule dates.

The P3 resource distribution algorithm was used to flow the existing and new scope (scope additions, deletions and changes) over time.

The renormalization takes the original baseline planned distribution to the renormalization date, the P3 distribution of new and existing scope after the renormalization date and shows a step change associated with the scope increase between the two curves at the renormalization date. (See Appendix C for a graphical representation.)

The weekly reporting cycle and the focus on earned value by management had the result of significantly improving the task status reporting by both OPG and contractor trades staff. Several informal earned value training sessions were given to trades staff and field supervision during the early part of the project.

It is apparent from the performance data produced that there was a tendency to over estimate progress on tasks at an early stage resulting in lower performance towards the end of the task; this is not a problem with relatively small tasks, however, on larger tasks lasting a number of weeks it can lead to an early over estimation of project performance. It is necessary to establish independent means of validating progress on large tasks where breaking the task down into smaller sub tasks would not make sense.

OPG staff reported both hours and percent complete in PassPort and then auto migrated the hours worked into TEMPUS for reporting purposes. The Wizard time reporting tool did not accommodate percent complete so contractors independently reported percent complete in another tool and batch updated this data into P3. The independent reporting of contractor hours and percent complete lead to inconsistencies between earned and actual hours at a task level and has remained a low level irritant through the life of the project. Of course variations at the task level between earned and actual hours reported are eliminated upon task completion.

The benefits seen by management of the earned value report-

Appendix A – Earned Value Tabular Report

PA RTS Earned Value Report
(hours, including Support)

Baseline

Weekly Period Ending

	2005											Project Life-to-Date			
	Planned (from baseline schedule)			Earned (from weekly schedule update)			Actuals (from Wizard and Tempus)			Progress Indices		Percent Complete Against Current Schedule			
Work Group	Last Week's Cumulative (1)	This Week's Cumulative (2)	Period (2) - (1)	Last Week's Cumulative (3)	This Week's Cumulative (4)	Period (4) - (3)	Last Week's Cumulative (5)	This Week's Cumulative (6)	Period (6) - (5)	Cumulative SPI (4)/(2)	Cumulative CPI (4)/(6)	Total Planned (Current Schedule) (7)	% of Current Project	Total Earned (2003 to-date) (8)	Percent Complete (8)/(7)
Black & McDonald															
Babcock & Wilcox															
Comstock															
OPG Excluding Valves															
Siemens															
Performing Org TBD															
OPG Valve Crew															
Total Project															

Sub-Project	Planned (from baseline schedule)			Earned (from weekly schedule update)			Actuals (from Wizard and Tempus)			Progress Indices		Percent Complete Against Current Schedule			
	Last Week's Cumulative (1)	This Week's Cumulative (2)	Period (2) - (1)	Last Week's Cumulative (3)	This Week's Cumulative (4)	Period (4) - (3)	Last Week's Cumulative (5)	This Week's Cumulative (6)	Period (6) - (5)	Cumulative SPI (4)/(2)	Cumulative CPI (4)/(6)	Total Planned (Current Schedule) (7)	% of Current Project	Total Earned (2003 to-date) (8)	Percent Complete (8)/(7)
B1 - Heat Transport															
C1 - Moderator / ECI															
D1 - Boilers															
E1 - Nuclear Support															
F1 - Turbine, Generator															
G1 - Cooling Water															
H1 - Feedwater															
I1 - Conventional Support															
J1 - SDSE / Reactor Shutdown															
K1 - DCC / SDSA / Regulating															
L1 - Electrical															
M1 - Fire Protection															
N1 - Fuel Handling															
O1 - Ventilation															
Z1 - Startup Sequence															
Actuals not in P3															
Total Project															

Comments:

	Total Plan	Remaining to Go
Baseline Schedule		
Weekly Schedule		
Difference		

ing of field trades staff lead to an expansion of earned value reporting into design engineering effort associated with the preparation of the 850 modification packages. Again, early earned value reporting indicated potential problem areas in time for management to take corrective action which in this case lead to improved estimating of remaining scope and re leveling of functional staff to avoid bottlenecks.

4.0 Future Plans

The following refinements are planned:

Extend earned value reporting to other areas of project work programs. Design Engineering has been recently incorporated and task work planning is to be incorporated.

Improve the alignment between schedule and time reporting cycles. Currently the schedule update day is Thursday, whereas the time reporting update is Wednesday. The schedule update will be brought into line with the time reporting cycle.

It is necessary to maintain an independent method of reporting progress of large tasks to ensure that early over estimation of performance is avoided. The capability of Wizard to measure progress through commodity based tracking proved to be ineffective and this method was dropped during Unit 1 RTS.

Continue to automate update and reporting processes so that time can be spent analyzing data rather than manually collecting, sorting and reporting on data.

5.0 Conclusion

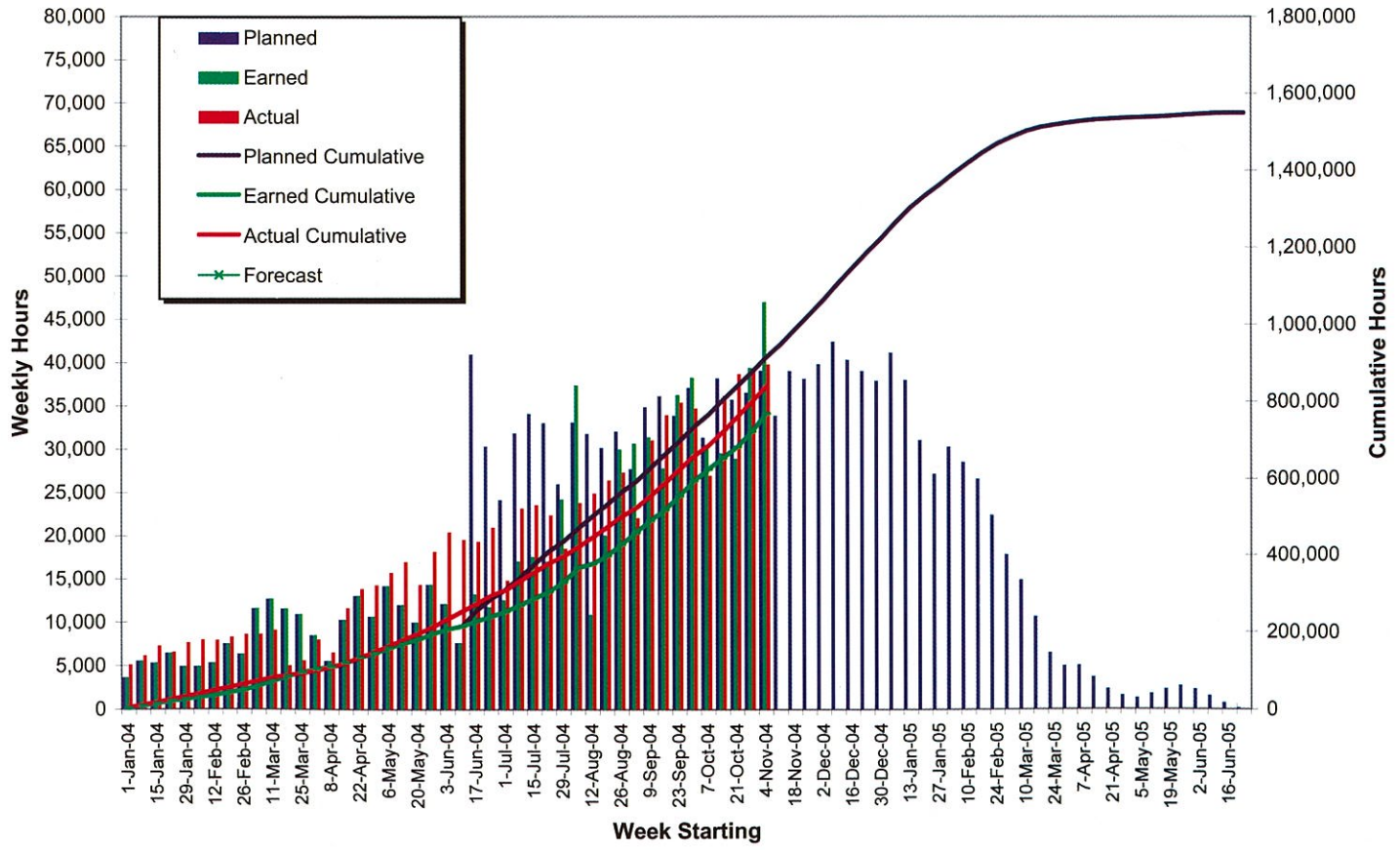
The use of SPI and CPI data has proved to be a reliable predictor of project performance; along with traditional reporting of task work-down curves and critical path analysis it has provided management with credible data on which to base decisions. The earned value approach may also be applied to planned outages.

SPI provides a much earlier indication of potential schedule slippage than either critical path analysis or task work down curves.

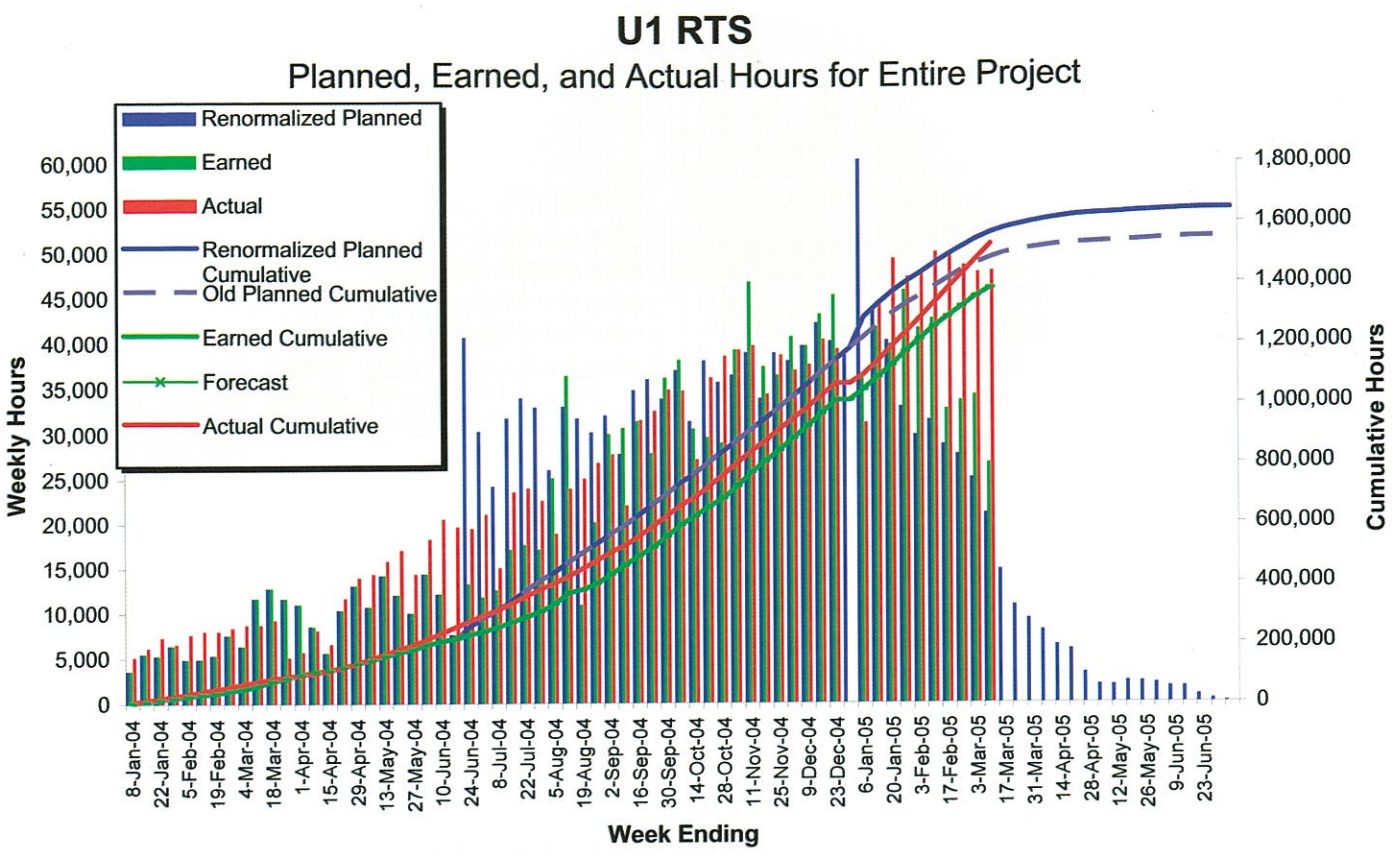
On large projects there is a need to automate data streams and update processes as much as possible to be able to free up analyst resources to complete schedule analysis rather than spending considerable time in project reporting.

There is a need to develop expertise to quickly analyze potential problems in batch updates such that errors can be corrected prior to issuing reports.

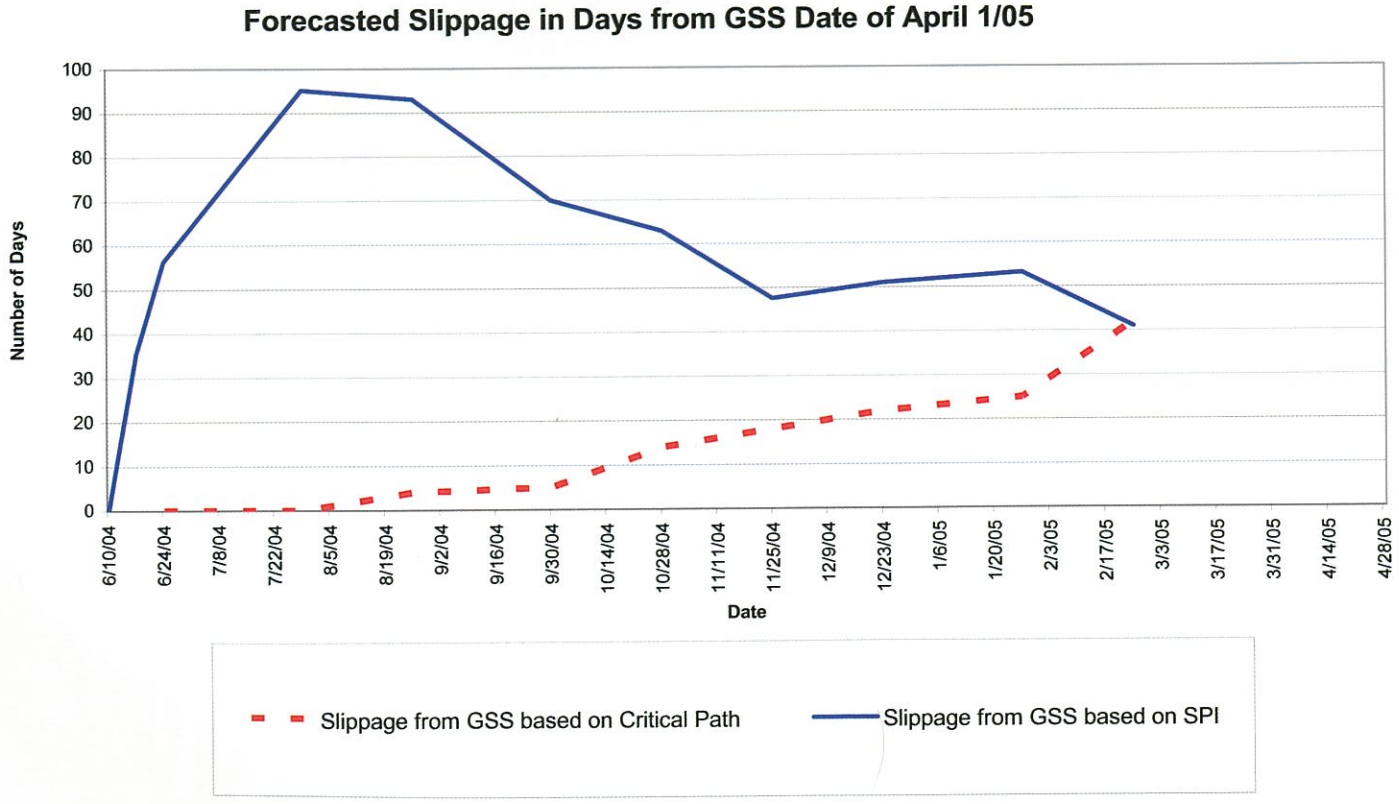
Appendix B – Total Project Earned Value Curve

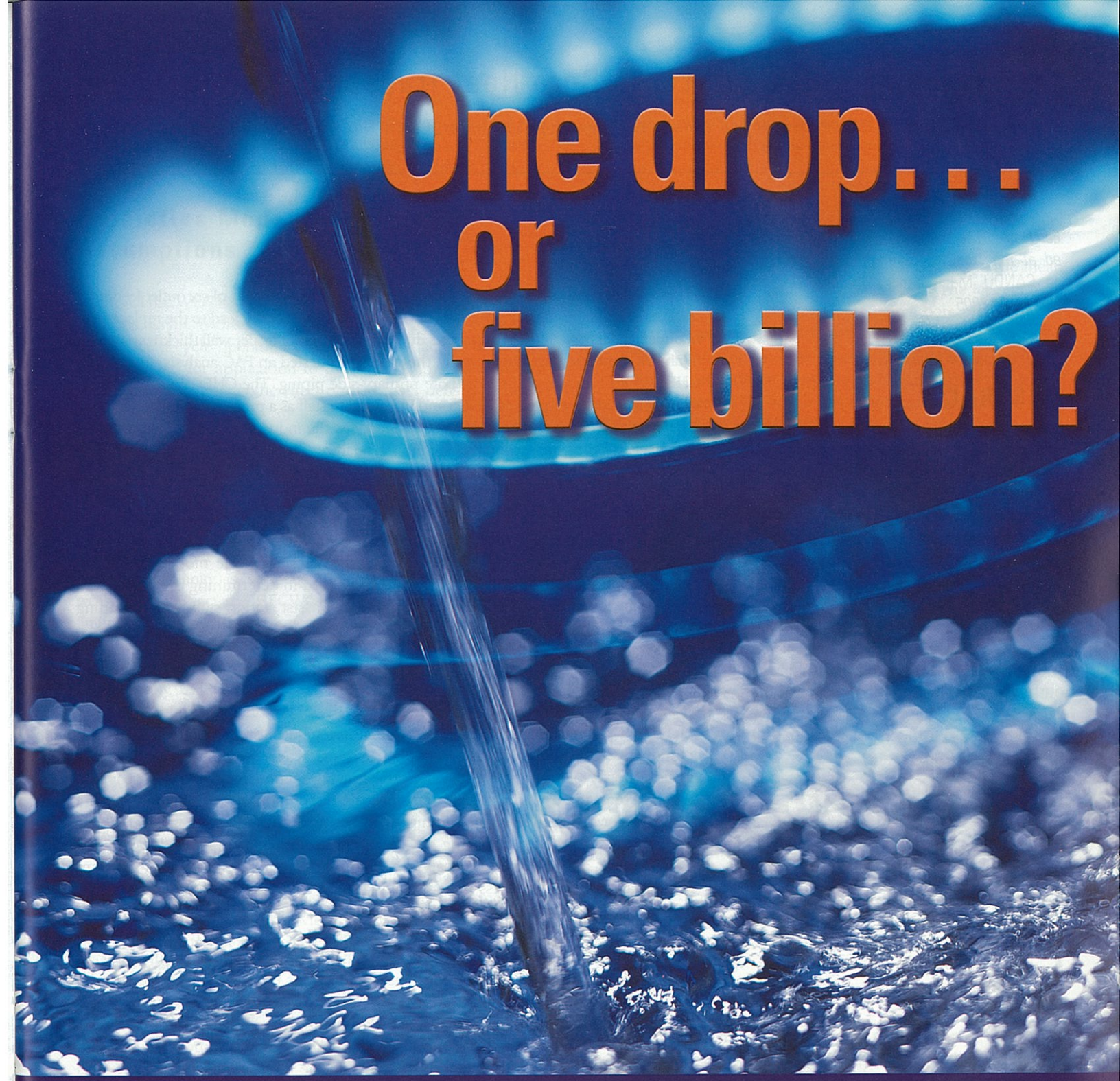


Appendix C – Total Project Earned Value Curve after Renormalization



Appendix D – Predicted schedule slippage using earned value data:





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Wall Thinning of CANDU Large Bore Heat Transport System Piping

Christopher Schefski, John Pietralik[1] and Zane Walker[2] and Ron McAlister, Omair Naeem[3] and Art Guillermo[4]

Ed. Note: The following paper was presented at the 7th CNS International Conference on CANDU Maintenance, *Toronto, Ontario, November 2005*

ABSTRACT

A review of the ultrasonic pipe thickness measurements from the Periodic Inspection Program at Darlington Nuclear Generating Station and Point Lepreau Generating Station have indicated greater than anticipated wall loss of the large bore Primary Heat Transport System piping. The rate of wall loss, using CHECWORKS(tm) (Chexal-Horowitz Erosion/Corrosion Workstation) to assist in the analysis, is similar to the rate of wall loss found in the outlet feeders. This wear rate is a plant life aging issue and does not pose an immediate concern due to the significant wall thickness of the large bore piping.

1 Atomic Energy of Canada Limited, Chalk River, Ontario

2 Atomic Energy of Canada Limited, Mississauga, Ontario

3 Ontario Power Generation, Darlington NGS, Bowmanville, Ontario

4 New Brunswick Power, Point Lepreau GS, Lepreau, New Brunswick

Introduction

Flow accelerated corrosion (FAC) has resulted in the replacement of six outlet feeders at the Point Lepreau Generating Station (PLGS), and may eventually lead to the replacement of outlet feeders at a number of stations due to a reduction of feeder wall thickness. As part of an FAC condition evaluation study, the utilities requested an FAC analysis, including a CHECWORKS model of the large bore primary-side piping. The CHECWORKS models were created at the request of DNGS and PLGS utility staff as a proactive approach in dealing with the FAC issue. The CHECWORKS code is the industry standard for predicting FAC rates in large bore secondary-side piping, analyzing measured ultrasonic pipe thickness data, and providing an organized structure for storing data.

This paper will focus on the wall loss due to FAC on the large bore components in the main HTS system. Ultrasonic pipe wall thickness measurements were used to calculate wear rates and to correlate the CHECWORKS predicted wear rates. The CHECWORKS model provides a relative ranking of susceptible modelled components without inspection data. This model has assisted in determining the rate of wall thinning in the HTS susceptible locations, and can assist station staff in determining inspection locations for further inspections.

Background

FAC is a mechanism that results in wall thinning in piping systems and process components. FAC takes place in power plant systems, where the protective oxide layer consists mostly of magnetite and where the flowing medium is water. Its wear rate is greater than the usual corrosion rate since the dissolution of the magnetite by the flowing water can accelerate the thinning significantly. CHECWORKS, a comprehensive software package for managing FAC concerns in the secondary side, was applied to supplement and improve the analysis of the existing periodic inspection program (PIP) ultrasonic wall thickness measurement at both DNGS and PLGS, and provide a relative ranking of the thinning rates of the other modelled components in the HTS.

In October 2003, a joint meeting between Feeder Integrity Project and Darlington Components & Equipment representatives was held to discuss the possibility of wear due to FAC on large bore HTS piping. The intent of this initiative was to explore the extent of condition of the feeder-thinning problem, as well as to address the concerns raised in the 2002 Self Assessment of the Darlington Pipe Wall Thinning Program. According to the Self Assessment, although the PIP does monitor pipe wall thickness at a few locations on the HTS, it is suspected that the limited number of these sites may not detect all the areas of potential wall loss. This is a concern because the basis of the PIP inspections is that they are merely confirmatory checks because FAC was not thought to be a problem in the HTS.

In a follow up meeting held in December 2003, Darlington Components & Equipment presented a list of potential inspection locations on the HTS. These locations were chosen based on a combination of factors including velocity, temperature and geometry (velocities and temperatures were extracted from a fluid dynamics model of the HTS). It is interesting to note that this list also included the locations that were already being inspected under PIP (i.e. 22" elbows at ROH). Since PIP inspections have been taking place since the beginning of plant operation, they provide a source of baseline data that has proven invaluable in assessing wall thickness trends over time.

Fortunately, this list of inspection locations was compiled in time for the Darlington Spring Outage. However, due to dose implications, Darlington was forced to drastically reduce the scope inspections on the HTS. As of the date of this publication, Darlington has completed HTS inspections on all four units.

Predictive Model Inputs and Assumptions

The CHECWORKS model required a large amount of input data. As CHECWORKS was developed to predict FAC rates under steam-cycle operating conditions, two factors needed to be considered for application to the HTS: 1) the difference in water chemistry, and 2) the effect of the higher density of heavy water on flow rate.

Water Chemistry

Three of the eight factors that affect the predicted wear rate in CHECWORKS are related to water chemistry, namely pH (or alkalinity), hydrazine concentration, and oxygen concentration.

CHECWORKS is designed to model corrosion in the steam cycle, where pH (alkalinity) is controlled using a volatile amine. Amines are weak bases, however, so CHECWORKS does not reproduce the alkalinity of the HTS where pH is controlled using the strong inorganic base, LiOH. Because of this limitation, the investigation was done at an alkalinity more representative of the steam cycle than of the HTS. Consequently, CHECWORKS was used only to provide a relative ranking of thinning due to FAC in the HTS components modeled based on the hydrodynamic conditions in the piping components.

Flow Rates

The mass flow rates that were used in CHECWORKS had to be adjusted to compensate for the difference in density between heavy water and light water in order to keep the velocity the same. Operating conditions, including mass flow rates, were determined from design manuals, actual plant flow measurements, system engineer interviews, and calculated hydraulic results as provided by station staff. The corresponding flow rates for light water were calculated and input into CHECWORKS.

Other Input Data

Temperature and velocity for CHECWORKS were provided by station staff and originally were produced by fluid dynamic codes, design manuals or design drawings. These values were validated against actual plant measured data. The data are valid for operation at 100% reactor power level. Pipe diameter and wall thickness were taken from the design drawings.

Measured Ultrasonic Data from PIP Inspections

A correlation is established between the CHECWORKS predicted wear rates for inspected components, and the measured wear rates based on ultrasonic testing (UT) field data for the same components. CHECWORKS uses this correlation to adjust the relative wear rates for the components without inspection data, based on the individual hydrodynamic conditions of the components.

Feeder Data

A typical feeder with measured data was added to the model for two reasons:

- The feeder data is relatively accurate due to being the mean value of a large number of similar feeders. The feeders have similar operating conditions as the large bore piping, therefore, they provide a good representation of wear.
- EPRI recommends at least three data points for determining a correlation between predicted and measured wear rates for the components for which inspection data are not available.

For the DNGS CHECWORKS model, a feeder elbow was used to assist in establishing a correlation between predicted wear rates and measured wear rates. A first bend in an outlet feeder with a 2.5" diameter was modeled. A mean measured wear rate was used from each outlet feeder that had a 73ʃ bend angle, a distance of 0.6" between the Grayloc fitting and the feeder bend, and a flow velocity between 14-14.5 m/s. The mean measured thinning rate for 2.5" outlet feeders is 88 ìm/EFPY in Unit 1 at DNGS. For all four units combined at DNGS, the average thinning rate is 80 ìm/effective full power years (EFPY).

The geometry codes in CHECWORKS were determined from design data, assigning relative wear rates based on the relative distance of upstream components and the bend angle. CHECWORKS has two types of bends to choose from when modeling elbows, 45° and 90° elbows. From reviewing feeder data, it is expected that the elbow modeled in CHECWORKS as a 45° elbow is within 20% of the actual wear calculated for a 73° elbow.

The first bend of a 2.5" outlet feeder elbow was modelled as a 45° elbow, with a radius/diameter ratio of 1.5, as calculated from information in "Darlington Nuclear Feeder Geometry Memorandum" [1]. A velocity of 14.5 m/s was used giving a CHECWORKS correlated wear rate of 78 ìm/EFPY.

Similarly, in the PLGS CHECWORKS model the first bend of a 2.5" outlet feeder elbow was modelled as a 45° elbow, with a radius/diameter ratio of 1.5. A velocity of 14.5 m/s was used in the model with a mean measured wear rate of 110 ìm/EFPY.

UT Data on Primary Piping

CHECWORKS is intended for large bore components made to specification as per ASME B 16.9, "Factory Made Wrought Buttwelding Fittings" [2]. Large bore is defined as components greater than 2" in diameter. Correlations are applied to the CHECWORKS predicted data (determined by velocity, pH, geometry, material) based on measured wall thickness data on the large bore piping. The CHECWORKS model also determines calculated wear rates from PIP measured data based on the point-to-point method. UT measurements performed as part of the PIP were used in the correlation of the predicted wear rates calculated by CHECWORKS. The PIP inspection revisits the identical points measured in previous inspections as demon-

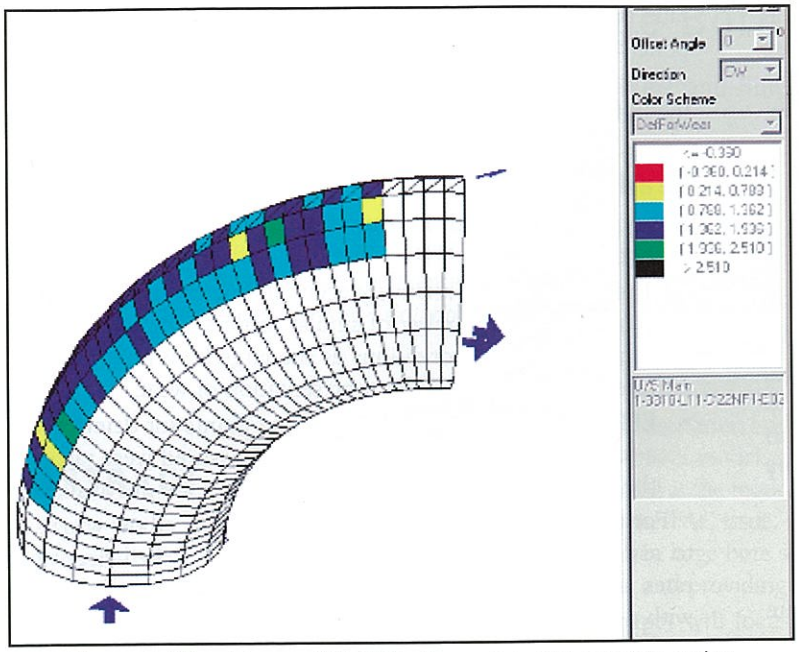

Figure 1 UT grid on a 22" HTS elbow showing point-to-point measurement differences.

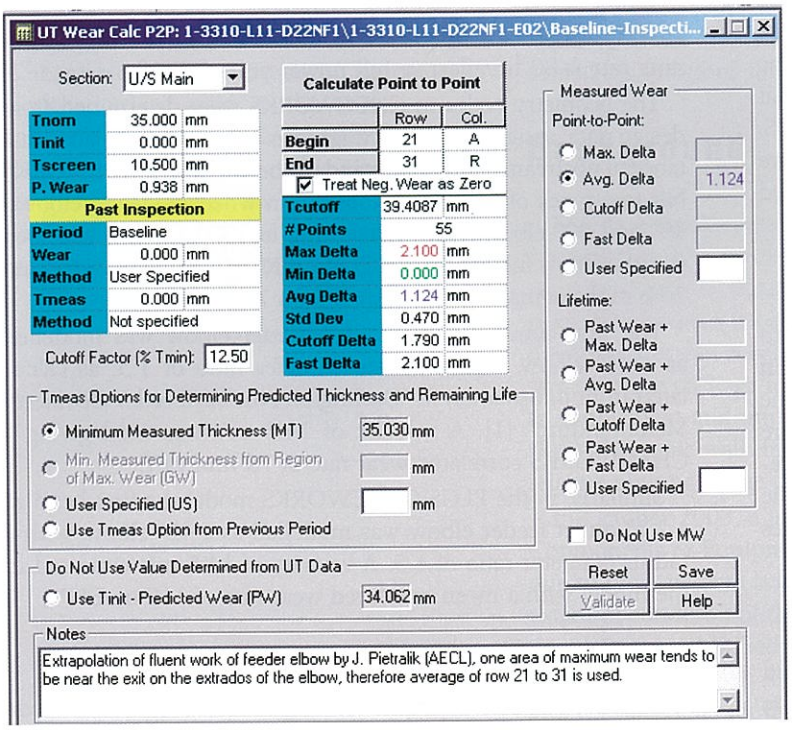

Figure 2 Average delta determined by point-to-point method between PIP inspection in 1990 and the inspection in 2004, Unit 1.

strated in Figure 1, then point-to-point calculation can be used for determining wear as shown in Figure 2. The point-to-point method is useful in confirming counterbore areas, determining the initial thickness of the manufactured components, and confirming the wear calculated by other wear methods. DNGS has baseline data taken before the units went into service; therefore, the usual uncertainties of initial pipe wall thickness and manufacturing variance are virtually eliminated from the wear rate calculations.

Using the average delta method[1] for the 22" elbow downstream from the outlet header, CHECWORKS calculated a lifetime (10.46 EFPY) wear of 1.124 mm, as shown in Figure 2, resulting in an average FAC rate of 107 ìm/EFPY. Other measured 22" elbows in the HTS and a typical 2.5" outlet feeder elbow with a mean wear rate were used to correlate CHECWORKS predicted wear to the measured wear.

The PIP grid data for thickness measurements were all on 22" elbows downstream of the outlet headers. The elbows had a grid on the extrados of every elbow and on the intrados of most elbows. A Fluent model simulating the flow and mass transfer in an elbow predicts that the maximum FAC wear rates occur in the extrados of the downstream end of the elbow and on the intrados at the upstream end of the elbow. Transferring these regions of maximum wear to the 22" elbows, we calculated UT wear calculations in the extrados. The wear in the intrados area could not be calculated because the thickness measurements were too scarce. This region, however, is typically thicker that the extrados region, and, therefore, it is expected not to be critical.

Due to the large manufacturing variance in the wall thickness of the 22" elbows, an average of the point-to-point wear at the extrados downstream end of the elbow was used as the maximum wear for the component. No readings were removed from the calculations, despite some questionable values. FAC wear affects large areas, and is not usually a localized wear mechanism, therefore, averaging the wear in an area at the downstream end of the elbow in the extrados area, will average out any possible erroneous data, with only minimal effects to the calculated wear rates. The maximum wear rate found was then applied to the lowest reading in the counterbore area. The counterbore is where the end of the elbow has been machined to as low as 89% of nominal thickness for welding to the adjacent piping. As per EPRI recommendations [3], the wear is calculated outside the counterbore areas, and then the maximum wear is applied to the minimum thickness in the elbow (in this case, the lowest reading in the counterbore) to determine the remaining life of the elbow. To ensure that the lowest reading is found, the 14-probe bracelet technology, similar to the techniques used for feeders, is recommended in critical areas, such as counterbores. This inspection technique would provide a quick overview of low counterbore areas ensuring low readings were not missed. The grid technology cannot detect all low readings because of possible small depressions. A design calculation giving local allowable minimum thickness in the counterbore area may relieve the need to conduct detailed inspections in the counterbore area.

Once a number of elbows have their maximum wear calcu-

1 The average delta method averages the differences in point-to-point measurements in a given area. In this case, an average delta is established in the region of maximum wear.

lated, the calculated wear is correlated to the predicted wear by CHECWORKS. This comparison calculates a ratio of predicted wear to measured wear. After correlating the CHECWORKS predicted FAC pipe wall thinning rates with the measured UT data, a predicted wear is calculated for the remaining components without inspection data. The correlation is based on the measured UT data at the locations listed in Table 1.

Table 1: Measured PIP Locations Used in DNGS CHECWORKS Thinning Calculations

PIP Identifier	Unit 1	Unit 2	Unit 3	Unit 4
TM-1	3310-L11	3310-L11	3310-L2	3310-L11
TM-2	3310-L17	3310-L12	3310-L6	
TM-3		3310-L17		

A modified point-to-point method offered in the newest version of CHECWORKS calculates wear more accurately for shorter operating durations and when large manufacturing variances of wall thickness exist. In the case of the HTS elbows, significant manufacturing variance is present, and, therefore, the point-to-point method is the only viable option for calculating wear. In addition, DNGS has the PIP inspection measurements that were completed before the units went into operation, so the initial wall thickness of the 22" elbows are known. Because DNGS did not conduct chemical decontamination, the wear rates are not influenced by any potential wall loss due to chemical cleaning.

Similar results were found for the PNGS data, however the DNGS results are the focus of the paper as DNGS wear rates are based on baseline data before the units were put into service, allowing a more accurate determination of wear rates.

CHECWORKS Results And Discussion

The wear rates given by CHECWORKS for the DNGS 22" elbows vary from 68 ìm/EFPY to 107 ìm/EFPY. These wear rates are similar to those measured in the tight-radius bends of outlet feeders under similar velocity conditions. CHECWORKS predicted wear rates show that the elbows in lines between the reactor outlet header (ROH) and the steam generators (SG) are the highest wearing components in the HTS.

The wear rates given by CHECWORKS for the PLGS 20" elbows vary from 58 ìm/EFPY to 91 ìm/EFPY. These wear rates are smaller than the mean wear rate of 110 ìm/EFPY measured in the tight-radius bends of outlet feeders under similar velocity conditions. CHECWORKS predicted wear rates show that the elbows in the hot legs and the ROH header large bore nozzles are the highest wearing components at PLGS.

Even though the rates are rather high, the components tend to be considerably thicker than the nominal thickness. However, the FAC rate in the counterbore needs to be addressed. The calculated wear rate by CHECWORKS for elbows with counterbores is approximately 100 ìm/EFPY. (Typical industry practice is to use the calculated predicted rate, in this case ~100 ìm/EFPY, with a tolerance of ±50%. Therefore, the maximum wear rate should not exceed 150 ìm/EFPY). The wear rate and minimum measured thickness are known, at the time of writing, an allowable minimum thickness has not yet been determined by design. Because of that, predictions of the remaining lifetime for the components cannot be made.

Lower values of calculated wear for PLGS components can be contributed by possible trace chromium in the material. The CHECWORKS model assumes zero chromium. The higher values of calculated wear can be due to a variety of manufacturing and field fit-up issues.

To eliminate the effect of chromium on predicted FAC rates, measurements of trace chromium content are recommended for critical components. The measurements can use a portable chromium analyzer. Knowing the trace chromium content will assist in further refinement of the wear rate analysis.

Susceptible Locations For Inspection

From all the components modelled, the CHECWORKS model confirms that the most susceptible components in the HTS are those located between the ROH and the SG. The most susceptible components in the HTS are the elbows between the ROH header and the SG, for which baseline measurements exist. In the case of PLGS, the ROH large bore header nozzles are equally susceptible due to the higher velocities in the nozzles.

The CHECWORKS model does not take into consideration the effect of solubility of iron in the FAC wear rate calculations. Papers on feeders have shown that the solubility of magnetite can completely stop FAC due to oversaturation. The increases of the oxide layer thickness and low rates of corrosion in the inlet

Table 2: FAC Susceptible Locations for large bore HTS piping

System	Location	Justification
HTS – ROH to SG	Elbows	Most susceptible as per CHECWORKS predictions
HTS – ROH to SG	ROH outlet nozzle **(PLGS only)**	Equally susceptible as elbows as per CHECWORKS presictions
HTS – SG to RIH	Elbows	Susceptible as per CHECWORKS predictions, although high concentration of magnetite in heavy water should reduce the FAC rates. It is recommended that this issue be re-considered after the first inspection in these lines.

feeders support this statement. Therefore, the wear rate that was determined by CHECWORKS for the components between the SG and the reactor inlet header (RIH) should be mitigated to a certain degree due to higher magnetite concentration in heavy water. Field data indicates possible thinning between the SG and the RIH, especially at other CANDU stations. This apparent thinning may be due to measurement error or manufacturing variance, as the data are extremely limited. Because of data scarcity, it is recommended that a limited number of inspections of these lines be included in an outage scope until sufficient industry data confirm that the magnetite oversaturation sufficiently mitigates FAC in these lines.

Summary

The above analysis shows that FAC rates of large bore HTS components in the DNGS and PLGS are in the same range as those for outlet feeders and the rates may be significant in some cases. In addition, there is uncertainty about FAC in the large piping and in some systems because of lack of inspection measurements. Because of these factors, it is recommended that other CANDU stations conduct a similar analysis, until there is enough knowledge to accurately predict FAC in the HTS.

References:

[1] R.J. Nantais, "Darlington Nuclear Feeder Geometry Memorandum", NK38-REP-33160-10002-R001, 2002 July 8.

[2] "Factory Made Wrought Buttwelding Fittings", ASME B 16.9, 2003 February.

[3] V.K. Chexal, J.S. Horowtz and G.A. Randall, "Recommendations for an Effective Flow-Accelerated Corrosion Program", NSAC-202L-R1, 1301-01, EPRI Product, 1996 November.

Steam Generator Tubesheet Waterlancing at Bruce B

by Raj Persad[1] and Dave Eybergen[2]

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Abstract

High pressure water cleaning of steam generator secondary side tubesheet surfaces is an important and effective strategy for reducing or eliminating under-deposit chemical attack of the tubing. At the Bruce B station, reaching the interior of the tube bundle with a high-pressure water lance is particularly challenging due to the requirement to setup on-boiler equipment within the containment bellows. This paper presents how these and other design constraints were solved with new equipment. Also discussed is the application of new high-resolution inter-tube video probe capability to the Bruce B steam generator tubesheets.

Introduction

The accumulation of deposits (sludge) at the top of the tubesheet area (secondary side) of steam generators has significant negative effects for the plant. The most important effect is the corrosion of the tubes, which may in turn lead to Stress Corrosion Cracking (SCC) or under-deposit pitting.

B&W Canada has performed mechanical cleaning with pressurized water (Waterlancing) at many CANDU plants including:

- Embalse Nuclear Generating Station
- Darlington Nuclear Generating Station
- Pickering Nuclear Generating Station
- Wolsong Nuclear Generating Station
- Point Lepreau Nuclear Generating Station
- Gentilly Nuclear Generating Station

During the spring of 2005 a B&W crew performed tubesheet Waterlancing for the first time at the Bruce B Nuclear Generating Station. The physical constraints due to the boiler penetration seal (bellows) around the secondary side interface of the steam generator (SG) had a significant impact on the design of the on-boiler waterlancing equipment.

Bruce Waterlancing Methodology

A rigid flushing system is inserted along the no tube lane (NTL), which enables high-pressure water to be sprayed along the tubesheet between the tube rows. The rigidity of the system enables the water to jet between tubes from the NTL in the center of the steam generator to the shroud at the periphery of the bundle. This water carries the loose sludge with it to the annulus region (between the shroud & shell) where it is removed via a suction system. The jets must be accurately focused down the lane to avoid impingement onto the tubes, which prevents effective flushing.

The flushing sequence is then followed by a lancing sequence. Here a lance is inserted via the NTL down the intertube lanes and high-pressure water is applied vertically downwards. This high-pressure jet breaks up the hard sludge, which is deposited around the tubes.

The lancing sequence is then followed by a final flushing sequence.

High resolution in-bundle visual inspection is used to verify the effectiveness of the process.

Waterlancing Constraints

1) SG & Bellows Interface Region

The bellows may be viewed as a cylindrical can, which surrounds the lower region of the secondary side of the steam generator. It extends from approximately the tubesheet elevation to just above the 2nd support plate (~6ft. 1"). It has an internal diameter of 133" while the SG has an external diameter of ~96". This results in ~18-1/2" free space in which to move and place equipment in the SG. It is also noted that the bottom surface is tapered with a narrower gap of only 2-1/4" between the bumper blocks and the shell of the SG.

1 Babcock and Wilcox Canada
2 Bruce Power

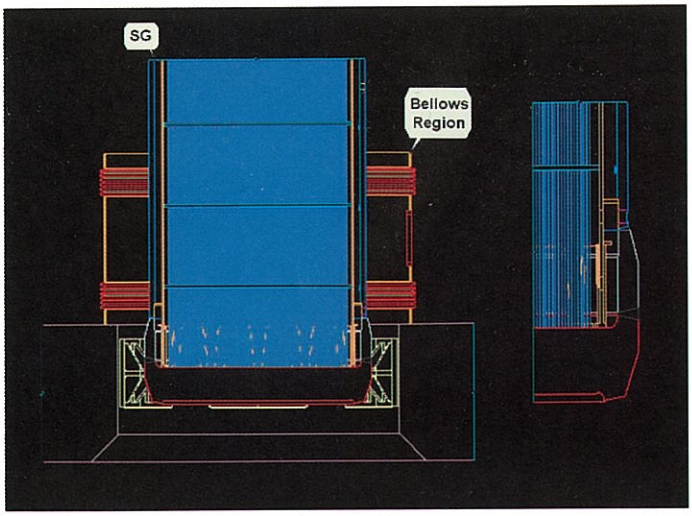

Image 1
Section of SG showing Bellows region

2) Handhole (SG) & Access Door (Bellows)

The SG has a lancing access port located 25-1/2" above the tubesheet. This port is 2-7/8" diameter and unlike regular handholes does not have any bolt holes nor flange. Rather, it is sealed during operation with a welded plug. This port is located along the X1-X2 axis, in the no tube lane (NTL) region. There are two other angled inspection port nozzles, which have an internal diameter of 2-1/2" and are located 90° from the NTL and 180° from each other.

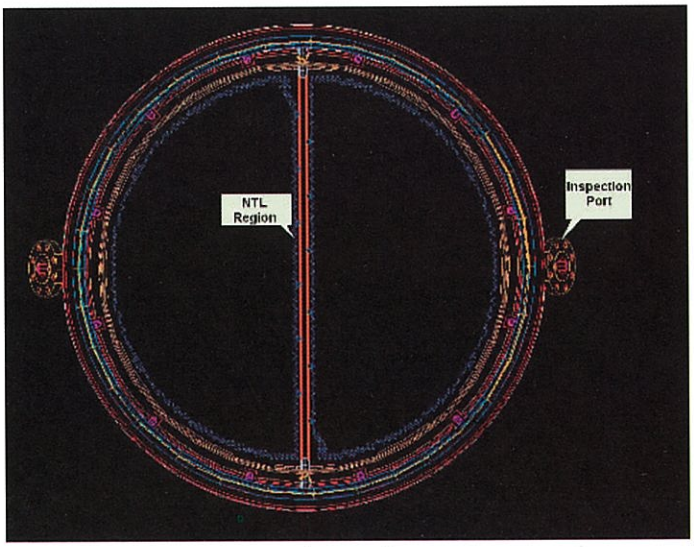

Image 2
Top View showing relationship of NTL & Inspection ports

The waterlancing access door in the bellows is 20-3/4" diameter and is located ~34-1/4" above the containment floor while the SG lancing port is located 6-3/4" above the floor. This results in a vertical distance of 27-1/2" between the centre of the handhole and the centre of the access door. The inspection port access doors were ~15" in diameter.

3) SG Internal Considerations

The SG has a shroud internal diameter of 82-1/4" and an external diameter of 84". The NTL is 2.69" wide along the length (82-1/4") of the SG.

The tubes are located along a .693" pitch and the tubes have an O.D. of .510". This results in an intertube free space of .183". Along the centre the longest intertube lane length is 37.6" from the NTL to bundle periphery.

The location of the flow restrictor ring around the outside of the shroud results in a minimum gap of ~1-1/2 " between shroud and shell. This ring is located below the level of the inspection ports thus restricting access to the tubesheet via the ports.

On-Boiler Waterlancing Equipment

1) Mounting Plate

The mounting plate is made from the same material as that used to manufacture the shell of the SG. This plate is then tack welded onto the SG, in-line with the handhole. This provides a means of mounting the other components onto the SG.

2) Rail

A rigid rail system is used to accurately position the flushing and lancing systems. This system spans the length of the boiler and is installed in segments due to the space limitations within the bellows.

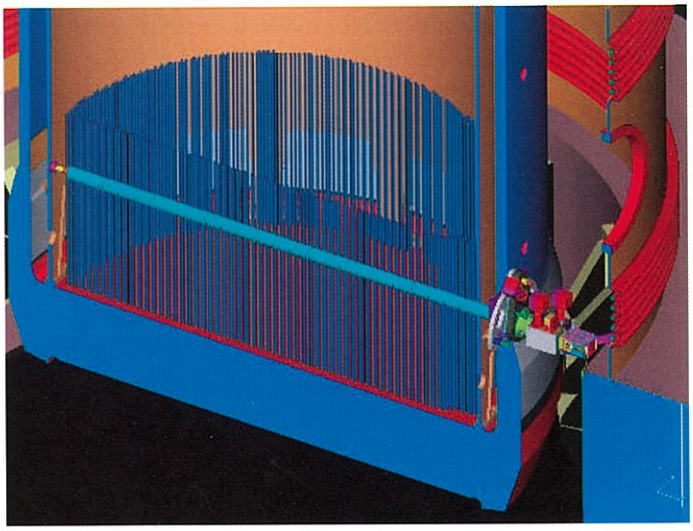

Image 3
On Boiler equipment set up in bellows region

The rails internal profile forms a track for other equipment to enter the SG in a very controlled manner.

3) Rotational Drive System

The rotational drive system is attached to the mounting plate and provides several functions. It serves as both a guide and stop for the rail during insertion as well as a structure for locating the locking pins to hold the rail in position. The rotational

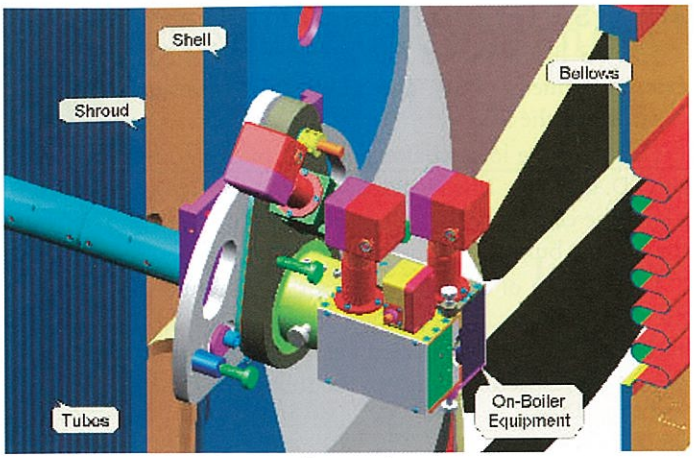

Image 4
On Boiler equipment set up in bellows region

drive allows the rail to be automatically adjusted to any required position. During the lancing cycles the rail is positioned with its track in a vertical position while during flushing the rail is rotated ~20 degrees from vertical. These orientations provide the maximum rigidity while also allowing the greatest use of the available space.

The linear drives that are used for insertion of guides and lances are also mounted onto the rotational drive system.

4) Flushing System

The flushing system is made up of a rotational head coupled with a guide. The stainless steel head houses spray nozzles and rotates at different angles spraying water down the intertube lanes at ~3000 psi (gauge). The head also houses an on board camera which provides the remote user with a method to verify that the system is in its appropriate location.

The flushing head is connected to a guide, which serves two purposes. It provides a conduit, which carries the electrical, pneumatic and hydraulic material from the outside of the SG to the head. It also allows the system to be driven linearly along the rail by the drive systems, located on the outside of the SG. The guide is made of an organic material cast into a guide thereby reducing the foreign material concerns that are normally associated with a segmented drive system.

The rigid flushing head is inserted in the rail and the flexible guide is bent as required to fit in the bellows area.

5) Lancing System

The lancing system consists of both the lance guide and the lance. The lance guide is driven independently to the appropriate intertube lane location and then the lance is driven independently down the lane. The lance sprays the high-pressure (9000 psi gauge) water from its starting point close to the NTL to the end of the lane at the peripheral region of the shroud. The system is then depressurised and the lance returns to its 'home' position within the head of the lance guide.

There are also two on-board cameras on the head of the lance guide. These provide a method of verifying the position of the lance guide at any point in time as well as the position of the lance. In addition the head also houses a proximity sensor, which senses the position of the lance within the guide head.

6) Inspection System

Due to the intertube region size restriction, fiberscopes were (until recently) the only technology that could be used to perform in-bundle inspections. These flexible optical fibre bundles have many disadvantages. They are delicate and the insertion of a 10 ft. scope in a suitable delivery system proves challenging. The scopes have a limited field of view of ~50°, and their resolution is in the 10,000 pixel range. The limited light supply thru the scope resulted in ~ 1" depth of view. These restrictions affect the reliability of the inspection since proper interpretation of the video requires a highly experienced individual.

Recent advances in miniaturization have allowed development of a new inspection strip consisting of a camera and two adjustable light sources mounted at the end of a delivery strip. The camera and light bundles are less than the 0.115" wide lanes. This integrated system is more robust. The field of view is ~80° and the resolution is in the 250,000 pixel range. The dual adjustable light supply results in clearer continuous video with a depth of view of ~6". These advantages results in a much clearer image of the intertube lanes including tube and tubesheet interface, hence a much more reliable inspection which can be readily duplicated (see images 5 through 8).

Image 5
Sludge on tubesheet and intertube region prior to flushing

Image 6
Sludge on tubesheet and intertube region prior to flushing

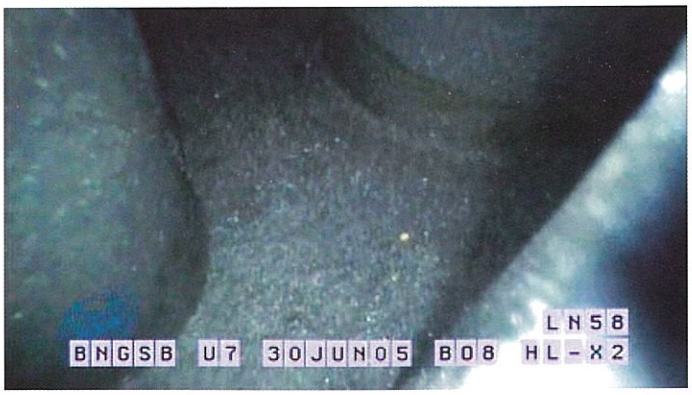

Image 7
Fine residue in intertube region after final flushing

Image 8
Localized sludge in intertube region after final flushing

An initial as found inspection of the in-bundle region showed a concentration of hard sludge in the central hot leg region. This hard sludge was concentrated in the tube to tubesheet interface and along the tubesheet, and resulted in focussed hard sludge lancing in both the 90° and 30° lanes in the central hot leg area. Loose sludge was found across the hot leg, and a lesser quantity of loose sludge was observed in the cold leg region.

In addition to the in-bundle inspections, a 360° annulus inspection was performed after the final flushing process. This was done to view the deposit of removed in-bundle sludge as well as heavier foreign materials in this region. This inspection resulted in vacuuming of the entire annulus to remove the loose sludge and other foreign material.

7) Linear Drives

The linear drives consist of two independent drive systems, which are mounted to the rotational drive.

After the flushing/lancing system is inserted into the rail then the motors are positioned in place. The linear drives are held by quick connect pins thus allowing the user to quickly remove and/or replace the drives as required. The linear drive system is used to drive both the lancing system as well as the inspection system.

8) Suction System

Previous waterlancing campaigns at Bruce utilized existing steam generator blowdown lines for suction. This required time consuming modifications to the piping systems and it was therefore decided to install suction hoses through existing inspection ports. The suction system was challenging to install due to the restrictor ring. The restriction at this ring is an abrupt change from 3-1/4 " to 1-1/2"" in annular gap. In addition the ring lays directly in the path of any object being inserted via the inspection port. This led to a suction system design incorporating three smaller suction feet (each no more than 1 " wide). Thus in total six suction lines were inserted, three from the Y1 and three from the Y2 inspection ports.

Results & Conclusion

The rigid rail was necessary to accurately position both the lancing and flushing systems in their right locations to be effective.

The lancing system proved to be very effective in removing the hard sludge and tube collars from the intertube region. This included the shadow areas behind the tubes.

The flushing system was effective in moving the bulk of the sludge to the periphery region however a fine residue remained evenly dispersed throughout the tubesheet.

The flushing parameters and suction system design will be modified to avoid both the fine dispersed residue as well as improve the removal of sludge from the annulus region. Flushing strategy including rotation speeds, flow rate and pressure will be further optimized. Tests performed at B&W have also shown that the flushing and lancing strategy (that is, the order in which lanes are cleaned) has a significant impact on the sludge removal capabilities of the system.

The upgraded visual inspection system provided excellent results and allowed for a very good assessment of waterlancing results and steam generator condition.

The vacuuming of the annulus proved beneficial and should be a continued practice in the future to remove deposits left in this area. These deposits if left may over time be redeposited in the inner bundle area.

An inspection of the annulus prior to the initial flushing operation is recommended to potentially vacuum large sludge deposits. This would have the benefit of ensuring a clear flow path for the suction system.

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CANDU Reactor Performance – 2005

by Morgan Brown[1]

Embalse NPP

The 2005 generation numbers are in for the CANDU reactors located around the world - it was a good year. These include KANUPP in Pakistan (a CGE design and not, very strictly speaking, a CANDU) and the two original reactors at Rajastan, India. The later 220 MWe Indian units, although strongly based on the Douglas Point design, are not included.

All the numbers - generation and capacity factor - are for gross production. Net production (i.e., delivered to the grid) is in the order of 93 to 95% of the gross output. This report relies primarily on publicly available Nucleonics Week data.

The matter of capacity factors is tricky - the highest gross capacities are used for all units, regardless of changes in capacities. This is particularly important for the Bruce units; Bruce Power leased CANDUs that were already derated The Bruce A units have 825 MWe turbines, but the gross capacity is 904 MWe to accommodate the steam production intended for the now decommissioned heavy water plant. The Qinshan units are rated as 728 MWe by some sources, but only 700 MWe by others. Using the maximum capacities lowers the capacity factor, but at least one cannot be accused of inflating the values.

Beginning with Ontario, Pickering-1 restarted in September 2005 after an extensive overhaul with upgrades. This is the fourth A-station reactor restarted (Pickering-4 and Bruce-4 in 2003, Bruce-3 in 2004) since the shutdowns of 1995 through 1998. Bruce Power announced, October 17, 2005, that it was proceeding with the refurbishment and retubing of Bruce-1 and 2, and would later refurbish the presently-running Bruce-3 and 4.

Ontario's 16 operating reactors generated 82,980,000 MWh in 2005 (78.6% capacity factor), a higher output than any year since 1996 when 19 reactors produced 84,700,000 MWh (68.7%). In 1997, 18 operating reactors produced only 76,250,000 MWh (65.8%). The 2005 CANDU output provided 51% of Ontario's electrical production.

The improvement in Ontario's CANDU output is partly due to the A unit restarts, but is also due to the improved performances from the reactors at Pickering B, Bruce B and Darlington. In 2005 these reactors generated a grand total of 68,015,000 MWh, more than any year since 1994 (70,250,000 MWh) or 1995 (70,020,000 MWh). Note that the Bruce B units are presently restricted to an average of about 92.5% of full power.

The ten CANDU 6 units throughout the world put in another stellar year in 2005, with a gross output of 53,005,000 MWh and a fleet capacity factor of 86.6%. This is a 1.4% decrease from 2004, due to reductions in the output from Wolsong-1 because of component aging. In early March 2006, Korea Hydro and Nuclear Power Company announced it would retube Wolsong-1 in 2009, and would limit output to 90% in the interim.

The Gentilly-2 and Point Lepreau capacity factors were 81.3% and 79.2%, and their peers at Embalse and Wolsong-1 attained 83.2% and 77.8%; all four of these CANDU 6 units are 23 years old. The ten year old Cernavoda-1 realized 89.8%, while Wolsong-2 and 4 reached 96.1 and 96.3%. The top-ranked CANDU 6 was Wolsong-3 with a remarkable 102.3% capacity factor, and the newest units at Qinshan attained 80.8 and 77.9%. The annual CANDU 6 capacity factor has averaged 86.0% for the past 10 years.

The final three operating reactors are KANUPP and RAPS-1 and 2. KANUPP began another lengthy outage in December 2005 to complete the overhaul and lifetime extension work. The output in 2005 was limited to 50 MWe (out of 137 MWe), and the resulting capacity factor was 25.3%. RAPS-1 produced no electricity in 2005, but RAPS-2 attained a capacity factor of 71.8%. RAPS-1 is undergoing an assessment for continued operation, in the light of the recent commercial operation India's first 540 MWe PHWR at Tarapur.

The total output from CANDU reactors around the world was a record 137,675,000 MWh in 2005. This equates to a fleet capacity factor of 80.1%, which includes all 16 operating Ontario reactors, the 10 CANDU 6 units, and the three Canadian-designed reactors in India and Pakistan.

I encourage readers to explore the CNS website (www.cns-snc.ca) for additional information on CANDU performance. A graph of CANDU reactor lifetime performance, versus reactor age, is updated monthly (see "Nuclear Info & Links", and the link "CANDU reactor performance graph"). Amongst other points, you will see my estimate that CANDU reactors, located in Canada, have delivered a grand total of 1,998,000,000 MWh (net) up to December 31, 2005. In addition, another 443,000,000 MWh (net) have been delivered by CANDUs located overseas.

Also, the CNS "Media" page contains a link to "CANDU Nuclear Station Reliability", an assessment of Ontario's reactor performance in 2004. This was written as a rebuttal to the tiresome (and wrong) phrase that CANDU reactors are "unreliable".

1 Morgan Brown works at AECL's Chalk River Laboratories but his "real job" is being the CNS webmaster.

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Dr. Ken Petrunik
Chief Operating Officer, AECL
2006 K.Y. Lo Medal Recipient

AECL and all of its employees congratulate Dr. Ken Petrunik on being awarded the Engineering Institute of Canada's K.Y. Lo Medal. The award, which is one of the highest distinctions made by the Institute, recognizes significant engineering contributions at the international level. Ken received the medal at the Institute's March 4, 2006 Annual Awards Banquet in Ottawa.

In addition to this most recent distinction, Ken is a Fellow of the Canadian Academy of Engineering, and an active member of both the Canadian Nuclear Society and the Canadian Nuclear Association. In 2004, he received an Achievement Award from the Organization of CANDU Industries for the successful completion of Qinshan Phase III, Units 1 and 2 in China, which Chinese Officials consider to be the best nuclear project that China has undertaken. Ken has also received a Leadership Award from the Canadian Nuclear Association for CANDU project management and the Friendship Award for technical support from the Chinese government, the highest award given to a foreign expert.

Congratulations Ken!

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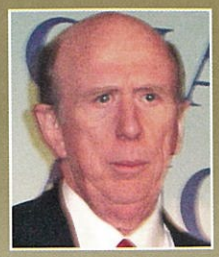
Robert Van Adel

Murray Elston

Duncan Hawthorne

Phil Ruffles

Jan Carr



David Wilkins

CNA Nuclear Industry Seminar 2006

"Urgent and decisive government action is needed" is closing message to record crowd

There was generally an "up-beat" atmosphere among the record breaking 530 delegates at the Canadian Nuclear Association's Nuclear Industry Seminar 2006, held in Ottawa, 22, 23 February 2006. The theme chosen for the event was ***Nuclear's Path forward - Building for Tomorrow.*** Interestingly, despite the strong overtone of the electricity situation in Ontario, four out of the eight principle speakers were from other countries.

Capturing the mood in his greeting to delegates at the opening reception, February 22, **Robert Van Adel**, CEO of Atomic Energy of Canada Limited, said, "What a difference a year makes: 2005 was a tremendous year for the Canadian nuclear industry". He referred to the statement by the Premier of New Brunswick, Bernard Lord on the Point Lepreau refurbishment, that it is "the most prudent, most balanced and most realistic approach to take." Then he expressively welcomed the Ambassador from China, Lu Shumin, Senator Joseph Day from New Brunswick and Cheryl Gallant, M.P. for Renfrew-Nipissing-Pembroke. In closing his brief welcoming comments he noted that recent polls showed that support for nuclear in Ontario had grown significantly.

That afternoon there had been a meeting of **Women in Nuclear Canada** (WiN-Canada), chaired by Susan Brissette of Bruce Power. She introduced Linda Keen, president of the Canadian Nuclear Safety Commission, who had agreed to be Honorary Chair of the WiN Global 2006 Meeting be held the end of May in Waterloo, Ontario. Keen noted that the meeting will be an opportunity to showcase the wide-ranging aspects of the Canadian nuclear program, from uranium mining, to nuclear power, to radioisotopes. Then followed guest speaker Cheri Collins, director of human resources at Southern Company Generation who spoke on "Servant Leadership: The True Spirit of Bringing Out the Best in Your People"

The CNA seminar began early the next day, February 23, with a breakfast. **Murray Elston,** president of the CNA, greeted the roomful of delegates and noted that there were 20 students sponsored by his organization. He turned over the podium to **Duncan Hawthorne,** CEO of Bruce Power and Chairman of the Board of CNA, who introduced the breakfast speaker, **Dr. Phil Ruffles,** of the U.K. Royal Academy of Engineering.

Ruffles titled his presentation, *U.K. Energy Policy and the Cost of Generating Electricity.* He began with a review of the government's White Paper of 2003 on energy and the environment. Even then the U.K had become a net importer of natural gas, despite the North Sea resources. By 2020 the report predicted 70% would be imported. On the question of security of supply he noted that one third of global gas reserves are in Russia and another third in the Middle East.

As part of the effort to reduce CO_2 emissions the U.K. government imposed a "carbon abatement" tax, which he noted is levied against nuclear generators. About one third of the energy consumed is in the form of electricity.

The report from the Royal Academy of Engineering is titled *The Cost of Generating Electricity* and examined a wide range of technologies (including poultry litter!!). A cost for carbon emissions was included, with nuclear being among the lowest. The cost of capital is a challenge for nuclear as is the perception of the "waste" issue. He noted that modern plants, such as that as Sizewell B, produce only about 10% of the spent fuel as that of the old Magnox ones. In closing he commented that, given the social and political dimensions, the choice of electricity generation will not be determined by cost alone.

The formal seminar was opened by Murray Elston, followed by Duncan Hawthorne. Before introducing the first speaker Hawthorne noted that, internationally, there are 26 nuclear units under construction. On the domestic front he referred to the challenge of refurbishing Bruce units 1 and 2 and commented that if the project were over-spent it would have very negative consequences.

Jan Carr, CEO of the Ontario Power Authority, was the lead-off speaker. He began with a review of the history of public attitudes toward nuclear. There was an early "honeymoon" period, which, he said, typically did not last, followed by actual, or perceptions of, cost overruns, delays, large debt, unsolved waste issue, and the need for governments to absorb the economic risks. Anti-nuclear groups also con-

tinued the association with weapons and security issues. Currently, he said, polls show that in Ontario there is roughly a 50% support for nuclear, but 95% for wind power.

Turning to the OPA *Supply Mix Advice Report* issued in December 2005, he began by emphasizing the word "advice". "The final decision on the supply mix is the prerogative of the [Ontario] government " he stated. Carr also mentioned that OPA is now working on a follow-up report, *Integrated Power Supply Plan,* which will include transmission and distribution.

Ontario has less generating capacity than a decade ago, he said. The OPA study had to recognize a number of factors: government policies (such as the proposed phase-out of coal plants); need for conservation; public preference for "renewables"; etc. Conservation and renewables can meet growth needs, he claimed. The challenge is the replacement of existing sources of supply. Natural gas plants are quick and relatively cheap to build but bring the challenge of "pay now or pay later" given the expected increase in gas prices. There are large North American reserves of coal but coal generation would only be considered if very clean technologies are developed. Nuclear could continue supplying the current, approximately, 50%, of total needs, as base load generation. This could be from refurbishing of existing plants or construction of new ones.

He then turned to the Integrated Power System Plan under way. This, he said, will look at the infrastructure implications of various supply mixes with a 20 year forecast. He commented that nuclear site locations are heavily influenced by the [existing] transmission system. The lead time for new transmission is comparable or even longer than for new nuclear plants, he added. Referring to the regulatory role of the Canadian Nuclear Safety Commission he emphasized that OPA would not be involved. Similarly, OPA will not be involved in the choice of technologies.

In closing he suggested that the industry begin a "multi-site, multi-technology" approval process since the pre-construction time for the various political and regulatory approvals is very long.

Next was a short address by the Ambassador for the United States of America, **David Wilkins.** He began by commenting that few Americans are aware that "Canada is not only [the US] top supplier of oil, but also of natural gas, electricity, and uranium". After expanding on that theme he spoke about the Energy Policy Act that came into effect in August 2005 and some of the associated activities, such as the $1 billion FutureGen program to build the world's first zero-emission coal-fired power plant. Although the US did not sign the Kyoto Protocol he stated that his country is spending more than any other on programs associated with the climate change problem.

Turning to nuclear power he noted that it provides about 20% of US electricity. Their Nuclear Power 2010 program is a joint government / industry effort to develop advanced nuclear technologies and bring them to market. The US is firmly committed to the Gen4 international program to develop technologies for the next generation of rectors, and to the International Thermonuclear Experimental Reactor, the proposed 500 MW fusion project.

Wilkins then showed a video in which Larry Craig, a senator from Idaho spoke primarily about the programs at the national nuclear laboratory in his state.

The last speaker of the morning was **Linda Keen,** president and CEO of the Canadian Nuclear Safety Commission. Under the title *Planning for Canada's Expanding Nuclear Program* she reviewed some of the events of the past year, spoke about the CNSC's proposed new regulations, and offered some thoughts about the CNSC structure and program.

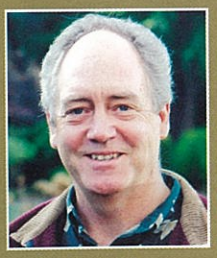
The CNSC led the Canadian delegation to the Third review Meeting of the Convention on Nuclear Safety in April 2005 and will lead the Canadian delegation to the Second Review Meeting of the Joint Convention on spent Fuel and Radioactive Waste Management in May 2006.

Noting that there had not been a new reactor licensed in over 25 years she stated that there is a need for a modern, twenty-first century regulatory framework that will apply to reactors "that may be in existence 100 years from now". The CNSC has produced an information document *The Licensing Process for New Nuclear Power Plants in Canada.* (See General News) It is the precursor, she noted, to a series of regulatory documents which are being developed for the licensing of new power reactors.

When questioned about her comment about "more than 10 years" for a new nuclear plant, she replied that she was including the five or so years to go through the Environmental Assessment process and CNSC licensing. She warned that the CNSC is already experiencing staff shortages and if new staff are not approved and hired there would be delays in the licensing process.

On the CNSC mandate she reiterated statements at previous meetings that an independent regulatory body is needed to assure public confidence and trust. The CNSC puts significant effort into accountability and transparency, she added.

Linda Keen



Patrick Moore

Ken Nash

Lu Shumin

Maria Argiri

Shown following the WiN Canada meeting are (L to R) Susan Brissette; Cheri Collins, guest speaker; Duncan Hawthorne, CEO Bruce Power, primary sponsor; Linda Keen, president CNSC and Honorary Chair WiN Global 2006

In closing she warned that the CNSC does not regulate in a vacuum. Industry's actions and performance also shape public attitude, she said. The onus is on licensees to pursue a culture of safety which generates trust and confidence among Canadians. "You must be 'world class' in your own fields", she stated.

(A slightly edited text of Ms. Keen's presentation is reprinted in this issue of the CNS Bulletin.)

At lunch, **Patrick Moore**, co-founder of Greenpeace and now chairman of Greenspirit Strategies Ltd., spoke on *An Environmentalist Revisits Nuclear Energy.*

He began with photos and comments about growing up on northern Vancouver Island and his early days as a "radical environmentalist". With a series of slides he spoke of his adventures with the ship Greenpeace and other campaigns that caught the eye of the media and led to the rapid growth of the movement to a "million-dollar" operation. Then, unhappy with the direction the organization was taking he separated, saying he decided to be "for", rather than "against".

We can provide for our needs, and maybe even our "wants" without degrading the environment, he stated, noting that the "energy efficiency" of our economy continues to grow. Referring to the topic of climate change he showed graphs of CO_2 and earth temperatures over the centuries and said that there is no proof that man-made CO_2 is causing the observed current global warming. On the Kyoto Protocol he noted that Canada had signed but was still increasing its production of CO_2. At least the USA and Australia, who did not sign, are honest, he said, and the US increase in CO_2 is half of ours. France, he noted, has 100% carbon free electricity, with 80% from nuclear and 20% from hydro. Transportation is the major source of man-made CO_2, and the biggest challenge is the behaviour of males, he commented.

Moore then spent some time talking about the advantages of tapping into geothermal energy. The earth beneath a typical (North American) house could supply 4 to 5 kW of energy, he stated.

In closing, he said the advantages of nuclear should be emphasized. TMI [accident of 1979] should be sold as a "success story", he proposed, with no one seriously injured. Despite Chernobyl, nuclear has been the safest form of electricity generation. Acknowledging the issue of proliferation, he observed that all technologies could be used for good or evil. High priority should be given to efforts to prevent the spread of nuclear weapons, he added.

He summarized his message by proposing: further development of renewable technologies (especially geothermal); expansion of nuclear generation; growing more trees; expanding conservation and energy efficiency; use of biotechnology to improve agriculture; development of a hydrogen transportation system.

The first speaker of the afternoon session was **Ken Nash,** speaking as chairman of the Nuclear Waste Management Organization, on *Canada's Longterm Waste Management Strategy.* He began with the statistic that there is currently about 35,000 tonnes of spent fuel in storage, of which 90% belongs to Ontario Power Generation. He briefly noted the extensive dry storage facilities and pointed out that the entire nuclear waste program is fully funded. The arrangements used to obtain community support for the Low and Intermediate Storage facility planned for the Bruce site is an illustration of the openness and transparency of the process, he noted. In closing he referred to the NWMO report issued in November 2005. While waiting for a decision from the government NWMO is proceeding with general planning for the implementation stage.

Next was the Ambassador of China, **Lu Shumin,** who began

by stating that China supports non-proliferation and the programs of the International Atomic Energy Agency. China has nuclear agreements with many countries, he added. His country is experiencing rapid economic growth, he noted, which has led to the similar rate of growth of the demand for electricity. Most generation is based on coal, he said but nuclear is very important with 19 units built or building. He referred to the domestic designed plants at the Qinshan site and the Canadian units of Qinshan 3, which, he noted, had the fastest construction of any nuclear plant in China. In closing he mentioned in passing, the very active program for the production of isotopes.

The final speaker was **Maria Argiri** from the International Energy Agency, who began by noting she was standing in for Dr. Fatih Biral, the IEA's chief economist.

Under the title of *World Energy Outlook - Strategic Challenges,* she began with setting out the factors of the IEA's "reference scenario, which assumed about a 50% increase in energy demand, 90% of which would be met by fossil fuels. New nuclear over the thirty year period 2000 - 2030 would be only one third of that of the previous thirty years. Oil production in Saudi Arabia, Iran and Iraq is predicted to grow to meet demand. Natural gas resources are primarily in the Middle East and Russia, she stated.

On the question of energy and poverty, she said that in 2030 there would still be 1.4 billion people without electricity.

Then she described an "alternative scenario", which still predicted considerable growth of demand. But through use of renewable sources, clean coal and perhaps nuclear the demand for oil in 2030 could be reduced from 115 million barrels per day to 102 mb/d. This alternative scenario still predicted a decline in the share provided by nuclear.

When members of the audience questioned the assumptions for nuclear she acknowledged that they were based on the situation and policies (in Europe) of a few years ago and expected that this year's report may show a different result.

CNA Murray Elston then offered some closing thoughts, beginning by repeating the closing words of the last speaker, **"Urgent and decisive government action is needed".** That could be the message from the seminar, he suggested.

He went on to thank the sponsors, the exhibitors, the speakers and the attendees. Finally, he reminded all delegates that if they filled in and deposited the evaluation form available in the exhibition area they would receive an irradiated golf ball that could improve their game by 10 percent.

PDF versions of the speakers' slides are available on the CNA's website <www.cna.ca>

Views of CNA Seminar

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The view of the regulator

Responding to Industry Growth

by Linda J. Keen[1]

Ed, Note: Following is the slightly edited (for space) text of the address given by Linda Keen, President and CEO of the Canadian Nuclear Safety Commission, to the Nuclear Industry Seminar 2006 of the Canadian Nuclear Association, 23 February 2006, in Ottawa.

As the title of your seminar implies - "Nuclear's Path Forward - Building For Tomorrow" - the Canadian nuclear industry is on the cusp of substantial growth in all areas, be it in power generation or uranium mining and milling, or industrial and medical uses.

In the face of this growth, Canadians can be assured that the Canadian Nuclear Safety Commission will remain steadfast in its mandate to protect the health, safety and security of our only client - the people of Canada - to protect the environment, and to ensure that Canada's commitments on the peaceful use of nuclear energy are respected.

Today, I would like to speak to you to about the modernized approach of the CNSC to regulate the growing nuclear industry in Canada and how the CNSC has been working to put into place a modern governance regime to demonstrate accountability and transparency in its regulatory oversight activities.

Look Back at the Last Year

Before I begin, I would like to discuss a few highlights from the last year and important progress on some key areas.

First, the CNSC's business case for new resources was submitted to the Government and we received some short-term funds. We are hopeful that decisions will be taken soon on our longer-term funding requirements. The CNSC will require these resources to avoid placing high-impact regulatory delays for initiatives that are critical to the industry and to Canadians.

Second, last April, the CNSC led the Canadian delegation at the Third Review Meeting of the Convention on Nuclear Safety. Canada participated fully as a Contracting Party and has made its report and its peer review questions and answers public. In an unprecedented move, I was asked by the 58 countries of the Convention to extend my Presidency of the Convention for the next three years.

Third, in September last year, after five years of implementing strengthened safeguards in Canada, the International Atomic Energy Agency drew its broader safeguards conclusion, for the first time, following assurances by the CNSC and industry of the absence of undeclared nuclear material and activities in Canada.

Fourth, the CNSC will be leading the Canadian Delegation to the Second Review Meeting of the Joint Convention on Spent Fuel and Radioactive Waste Management in May of this year. The [Canadian] report will be available on our website and will be the basis of the peer review later this year.

Modern Regulation

I would now like to turn to the subject of new nuclear energy projects and the modern regulatory practices underpinning the CNSC's approach to regulatory oversight.

Decisions have already been taken by industry to pursue refurbishment of part of the CANDU fleet - at Bruce, at Point Lepreau and, in part, at Pickering - and due diligence is being done on decisions affecting refurbishment of Gentilly-2 and life extension of Darlington.

Signals for the building of new power reactors in Canada have been growing over the last year. For example, the Ontario Power Authority's December 2005 report to the Ontario government recommended that the province either refurbish or replace the current fleet of nuclear reactors. However, there has not been a licence application, by any operator, to start a new reactor process - and it would be an operator - not a vendor, not a government - who would trigger this process.

The impact of such projects would be to dramatically increase the regulatory work of the CNSC. While we are already working on the refurbishments that I have named, and there is a potential for more, the building of new reactors will be an incrementally bigger challenge.

The CNSC has not licensed a new nuclear reactor in over 25 years. Consequently, we have been busy preparing for the development of a regulatory regime for potential new power reactors - one that reflects our modern regulatory regime, regulatory

The CNSC has not licensed a new nuclear reactor in over 25 years

1 President and Chief Executive Officer, Canadian Nuclear Safety Commission, Ottawa, Ontario

Our regulatory framework will be technology neutral

practices and the overall environment in which we operate.

Canadians should expect a modern, twenty-first century, world-class review of any new reactors and the CNSC is preparing to deliver that. We must ask, "How can we use the regulatory framework to bring the most modern safety oversight to reactors that may be in existence 100 years from now?"

There are some practical approaches to licensing and the timelines of applications. We intend to communicate openly to ensure that all interested parties are able to make informed decisions based on the CNSC's regulatory expectations for any new build.

In order to start this communication, the CNSC has produced an information document entitled *"The Licensing Process for New Nuclear Power Plants in Canada"*. This document is now available on the CNSC website (www.nuclearsafety.gc.ca).

The document describes the licensing process for any new nuclear power plant in Canada, based on the requirements of the *Nuclear Safety and Control Act* and its associated regulations. A number of other regulatory documents will have to be developed over the next five years to support an application to build a new power reactor. The first of these new regulatory documents is entitled *"Requirements for the Design of Nuclear Power Plants."* It should be ready for public consultation in the months ahead.

The CNSC's approach to the licensing of any new build is bound by several principles.

First, safety is the CNSC's priority. Other stakeholders, including operators, governments and vendors, will have different interests - such as economics, timelines, productivity and efficiency - but our job and mandate is safety.

Second, the CNSC's regulatory requirements will be aligned with international standards and practices to the greatest extent practicable. These are not American standards. They are international standards developed under the IAEA. They represent the world's collective knowledge and experience and can best ensure that Canadians can have confidence in our modern, internationally benchmarked, regulatory oversight.

Third, as an independent regulatory body, the CNSC does not make choices on technology. The CNSC is technology neutral in all areas of our mandate, including power reactors, and our regulatory framework will be technology neutral to the extent possible. Independence and objectivity on nuclear matters are key principles in ensuring the CNSC operates in accordance with its mandate and ensures public trust.

The final principle is that the safety case and the information submitted by a proponent in support of a new licence must be complete at the time the application is submitted. The better prepared the proponent at the initiation of the licensing process, the more effective and efficient the licensing process will be.

So, how will new reactors fit in with respect to other ongoing pressures facing the CNSC?

As we move forward in the new power reactor service line, the CNSC's first priority remains the safety of existing facilities.

Our second priority is the refurbishment of the current existing fleet of CANDU power plants.

The licensing of new nuclear power reactors will need to be third.

As such, proponents must give the CNSC ample notice in order to prepare. The CNSC will have to acquire new resources - both human and financial - in order to carry out the necessary work. The pressure on human resources will be particularly acute. The combined forces of a growing industry and a workforce with many nearing retirement present challenges. We are already experiencing difficulties in hiring staff. Without more qualified people, operators will be required to wait.

To address this pending and serious shortage, the CNSC has agreed to work with industry to support a conference that includes industry, research institutions and universities, to examine our future human resources needs and how we will address them. I cannot over emphasize that this acute shortage of qualified staff will affect our ability to respond.

Governance

The final area I'd like to speak to you about is governance.

As you have heard me state before in these seminars and in our regular meetings, independent regulatory bodies such as the CNSC are important in order to assure public confidence and trust in the effectiveness of regulatory oversight and trust in the nuclear industry.

Maintaining an arm's length relationship to government and industry is a critical element of sustaining that confidence. For this reason, the CNSC reports to Parliament through the Minister of Natural Resources rather than to him. As such, the Minister is answerable in general to Parliament, but it as President and Chief Executive Officer that I appear before parliamentary committees in accordance with the principles of ministerial responsibility and political neutrality in order to account for the governance of the agency and for our programs.

I welcome the clarification of the role and responsibilities of independent federal quasi-judicial administrative tribunals, such as the CNSC, in the new Government's recent document, entitled, *"Accountable Government (2006)."*

At the CNSC, we have put significant effort over the last five years into a governance regime that demonstrates our accountability and transparency. It can be summarized by answering three questions: What do we do, how do we do it, and how are we measured?

What do we do?

The CNSC is committed to an effective regulatory regime that is based on modern legislation and clear, modern, risk-informed regulatory approaches.

It is absolutely essential that my agency draws its direction

from Parliament through the clear direction provided by the *Nuclear Safety and Control Act*.

The nuclear regulatory regime is based more and more on international standards and experience and is being modernized as new and proven good practices and approaches are available. The CNSC has one of the broadest sets of regulatory responsibilities and is often chosen as a benchmark for its regulatory framework.

How do we do it?

The CNSC is founded on a strong regulatory culture based on integrity and adherence to shared values and ethics.

The CNSC has a Values and Ethics strategy and, this year, will be producing information that will help ensure that all of you understand our ethical commitments and assist us in meeting our objectives.

These are the basics, but there are other examples. The CNSC has already instituted an internal disclosure mechanism which is in advance of any formalized government requirement, to help staff disclose wrongdoing in a safe and constructive manner, and to protect staff against reprisals when they raise an issue or disclose wrongdoing in good faith.

We have also committed to a new Quality Management Program based on IAEA standards, the first major nuclear regulatory body in the world to do so.

Transparency and public confidence are cornerstones of our governance regime. Public confidence is based on knowledge of what we do and a sharing of our regulatory expectations and the results. The Commission is committed to openness and transparency.

How are we measured?

The Government of Canada institutes measures for reporting such as Annual Reports, Reports on Plans and Priorities, and Departmental Performance Reports.

In addition, measures for auditing - both internally through the CNSC's Audit and Ethics Group and externally by the Office of the Auditor General - are in place, as well as systems for the disclosure of travel expenses, hospitality and contracts. The CNSC adheres to these requirements.

But since our vision is to be one of the best regulators in the world, the CNSC also places a priority on measuring the quality of our regulatory practices. Accordingly, last year, I requested from the IAEA an independent assessment of our regulatory programs, starting with our power reactor program.

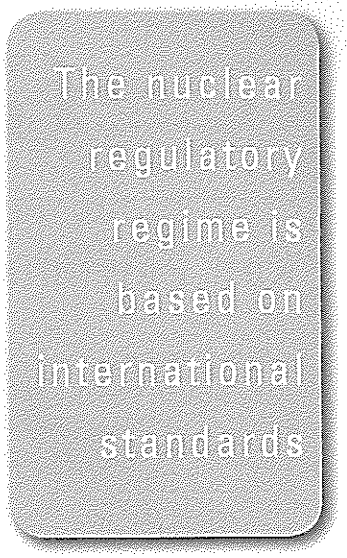
In preparation for this, we hosted colleagues from the United States and United Kingdom last fall, who are working together with us on our preparations for a self-assessment in advance of the formal International Regulatory Review Team assessment. The CNSC will make the results of this assessment public.

Other Emerging Pressures

As I stated earlier, there are other emerging pressures. It seems the nuclear industry is poised for significant growth in all areas of the nuclear fuel cycle, and the CNSC recognizes that power reactors are only a part of this growth.

The initiatives and issues that we anticipate will have a significant impact include:

- In mining, the potential development drilling, mining and milling of newly discovered uranium ore bodies and the planned expansion of uranium production from existing operations.
- In waste, the proposed Deep Geological Repository for low and medium level wastes at Kincardine, including the management of waste generated from the decontamination and demolition of facilities that are to be decommissioned.
- The November 2005 Nuclear Waste Management Organization (NWMO) report with its recommendations for permanent storage of Canada's nuclear fuel waste.
- In addition, we are seeing substantial increases in regulatory oversight work due to growth in the nuclear substances sector. For example, the number of licensed cancer treatment facilities increased by 86 percent between 2000 and 2004, with further and substantial growth in coming years due to changes to health care approaches.



Conclusion

Through all of the challenges the future will bring, the CNSC will continue to strive to be one of the best nuclear regulators in the world.

The CNSC is committed to a high level of effectiveness, while achieving our other objectives of transparency, efficiency and accountability.

Our governance structure will remain strong. We will continue to exercise due diligence and proactively undertake activities to further enhance our good governance practices.

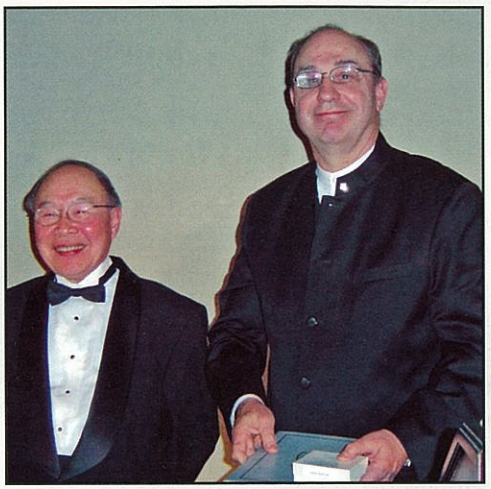
I believe that the CNSC has a clear vision of its purpose and mandate, is results-based, and has instituted the necessary processes and structure to deliver on its responsibilities and address emerging pressures.

As the regulator, the CNSC also plays an undeniable role in maintaining public confidence in the safety of facilities in Canada. But, the CNSC does not regulate in a vacuum. The industry's actions and performance also shape the public's attitude. The onus is on licensees to pursue a culture of safety which generates trust and confidence among Canadians. You must also be "world class" in your own fields.

Ken Petrunik Awarded EIC Medal

Ken Petrunik, Senior Vice-President and Chief Operating Officer of Atomic Energy of Canada Limited, was presented the K. Y. Lo Medal for significant engineering contributions at the international level, one of the most prestigious awards of the Engineering Institute of Canada, at the EIC Awards Dinner held in Ottawa, March 4, 2006.

Following is the citation read out at the ceremony.



Ken Petrunik is shown following the presentation of the K. Y. Lo Medal by the Engineering Institute of Canada at the EIC Awards Dinner, 4 March 2006 in Ottawa, with Prof. K. Y. Lo after whom the award was named.

Dr Ken Petrunik is currently Senior Vice President and Chief Operating Officer, Atomic Energy of Canada Limited (AECL). He is responsible for managing all aspects of AECL's commercial operations including major projects, services, and marketing and business development. He led the design, licensing, construction and commissioning of the Embalse station in Argentina, Cernavoda Unit 1 station in Romania, and Qinshan Phase III Units 1 and 2 in China. The Qinshan project is the largest project that Canada has completed to date in China and the project was delivered ahead of time and below budget. It is considered by senior Chinese officials to be the best nuclear project that China has yet undertaken. Ken currently has executive responsibility for the major refurbishment Projects involving CANDU(reactors.

The prestigious K.Y. Lo Medal, under the auspices of the Engineering Institute of Canada, is in honour of K.Y. Lo, Professor Emeritus of the University of Western Ontario and is awarded ***"in recognition of significant engineering contributions at the international level".***

Such contributions may include:

- *promotion of Canadian expertise overseas;*
- *training of foreign engineers;*
- *significant service to international engineering organizations; and*
- *advancement of engineering technology recognized internationally*

Dr Petrunik, by virtue of his outstanding career and service to the Nuclear Industry in the international field, is eminently suited to receive the K.Y. Lo Medal of the Engineering Institute of Canada.

During Dr Petrunik's 30 plus years with AECL, he has held a number of executive positions including Vice President, Projects and Services Business Unit, Vice President and Project Director, China, Regional Vice President Marketing, Vice President Operations, and Vice President Projects. Prior to executive appointments, Dr Petrunik's roles have included Director of Business Planning, Project Director Embalse (Argentina) CANDU 6 Project, Technical Manager Embalse, Engineering Manager Cernavoda (Romania), Senior Project Engineer Darlington, Senior Head, Process Design Engineering.

Before joining AECL Dr. Petrunik worked for Ontario Hydro, Imperial Oil and Gulf Oil. He has a Ph.D. from the University of Windsor in Chemical Engineering where he taught university for four years.

Dr Petrunik is a results-oriented executive who has created and led his teams with a direct personal involvement in commercial, technical and operational matters. Ken has a broad understanding of the power plant business and has developed excellent relationships and partnerships with domestic and international clients, promoting and executing clean and emission-free Canadian CANDU nuclear technology overseas. His multinational experience, including fifteen years offshore with AECL Projects, includes working with government ministers, consortia partners and technical and scientific staff. Dr Petrunik has received domestic and international awards for his accomplishments, including the Friendship Award, for technical support to China-the highest award from the Chinese government to foreign experts.

Dr Petrunik has indeed made "significant engineering contributions at the international level".

Nomination

Dr Petrunik's international career accomplishments and exemplary service to the industry speak for themselves and clearly fulfill the Award requirements. Dr Petrunik is a worthy and deserving nominee for the 2006 K.Y. Lo Medal of the Engineering Institute of Canada.

The Canadian Nuclear Society made the initial nomination to the EIC.

Petrunik is already the recipient of many additional honours over his distinguished career including: being named a Fellow of the Canadian Academy of Engineering, receiving a leadership award from the Organization of CANDU Industries for the successful completion of Qinshan and a Friendship Award for tech-

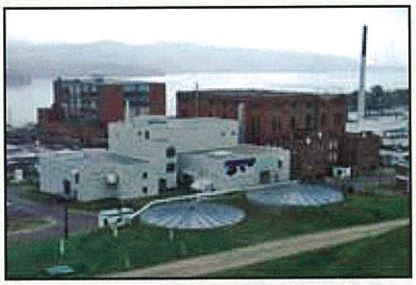
nical support from the Chinese government, the highest award given to a foreign expert.

In 2003 Ken Petrunik received an Outstanding Contribution Award from the CNS and CNA for his impressive record in setting up projects and bringing them to a successful conclusion, with special reference to the Qinshan project in China

Also at the EIC Awards Dinner, **Andrew (Drew) Wilson** was awarded the Sir John Kennedy Medal for his contributions to the science of engineering and the EIC. From 1958 to 1964 he was with the physics division of the Chalk River Nuclear Laboratory. Subsequently he was with the Science council of Canada, National Research Council and the Natural Science and engineering Research Council. Since retirement he has written a number of papers about the history of engineering in Canada.

AECL assumes ownership of MAPLE and NPF

MAPLE 1 start-up now October 2008



View of Dedicated Isotope Facilities at AECL's Chalk River Laboratories.

In late February 2006, Atomic Energy of Canada Limited (AECL) announced that it had assumed ownership of the Dedicated Isotope Facilities (DIF), which includes the two MAPLE isotope-producing reactors and the associated New Processing Facility (NPF) at AECL's Chalk River Laboratories.

This action comes after months of mediation between AECL and MDS Nordion, the original owners of these facilities. The resolution includes a 40-year isotope supply agreement between AECL and MDS Nordion. Under this agreement the DIF will be dedicated to the production and supply of isotopes to MDS Nordion. AECL will continue to supply radioisotopes to MDS Nordion from its existing facilities until DIF is operational.

Under the agreement, AECL will complete the commissioning of MAPLE 1 and NPF with an in service date of October 31, 2008; MAPLE 2 will be commissioned and in service by October 31, 2009. AECL will fund the completion costs of the project and the ongoing operating costs. AECL will also make a payment of $25 million to MDS for transfer of title and acquire $53 million in DIF related inventories from MDS.

In return, AECL will receive a share of net revenues from isotopes produced. MDS will also compensate AECL for safe storage and long-term management of wastes produced from the processing of isotopes at MDS Nordion's Kanata facility.

From now until late 2008 AECL will continue to supply MDS Nordion with isotope production from its NRU (National Research Universal) reactor and associated facilities in Chalk River under its current supply agreement with MDS. NRU produces, for MDS Nordion, the majority of the world's medical isotopes such as molybdenum-99, which is used extensively for diagnosis, and longer-lived isotopes used for cancer therapy.

Bruce and NB Power put refurbishment and restart on the web

Both Bruce Power and NB Power have decided to keep everyone informed about the progress of the restart of Bruce Units 1 and 2 and the refurbishment of Point Lepreau.

In January 2006 **Bruce Power** launched a new website to provide a quick and easy way to stay current on the Bruce A restart project. Linked to the home page of Bruce Power's main website at <www.brucepower.com>, the restart web pages provide a multi-media look at efforts to restart Units 1 and 2 at the Bruce A generating station.

The website features useful information, including:

- Video clips that illustrate how pressure tubes and steam generators will be replaced and describe how electricity is made at a nuclear power plant.
- An overall schedule showing what work needs to be done during the restart, who will do that work and how they are progressing.
- An easy-to-read chart of what companies are involved in the project and how to contact them for employment opportunities.
- Up-to-date information on our Environmental Assessment process
- A photo gallery of downloadable images
- A library of media releases and reports pertaining to the restart project, including the full project description and Bruce Power's agreement with the Ontario Power Authority

Also in January, **NB Power** created a brand new website <poweringthefuture.nbpower.com> to provide information on the refurbishment of the Point Lepreau nuclear generating station. It is linked to NB Power's home website.

This site offers an introductory video and information on timelines, activities and impacts on the community.

CNSC issues licensing process for new NPPs

On February 24, 2006, the Canadian Nuclear Safety Commission presented the document *Licensing Process for New Nuclear Power Plants in Canada* at a public forum in Ottawa. (CNSC president Linda Keen announced this document at the CNA Nuclear Industry Seminar the day before.)

Following is the "Executive Summary" of the report.

This document describes the licensing process for new nuclear power plants in Canada, taking into consideration the requirements of the Nuclear Safety and Control Act (NSCA) and regulations made under the NSCA.

This document covers only the major steps in licensing a new nuclear power plant. It does not address any approvals that may be required once a licence to prepare a site, or construct, operate or decommission a reactor are issued, nor does it describe the technical requirements used to support the assessment of licence applications.

The Canadian Nuclear Safety Commission (CNSC) is currently updating its regulatory framework for nuclear power plants. The updated framework will draw upon international standards and best practices, including the International Atomic Energy Agency's (IAEA) nuclear safety standards, to the extent practicable. The IAEA's standards set out high-level safety goals that apply to all reactor designs; that is, they are technology-neutral. Aligning the CNSC's regulatory framework for new nuclear power plants with international standards and best practices, allows the CNSC to build on advances in safety and on the experiences of the international regulatory community. Canadians, therefore, can be assured that any new nuclear power plants built in Canada will meet the highest standards for health, safety, security and environmental protection.

Ian Grant, director general of power reactor regulation, stated that the new "international" standards would be "technology neutral". He refuted the suggestion that "international" standards reflected the fact that most power reactors around the world are light water reactors. To a question he stated that the new standards would be applied to future refurbishments.

When questioned about the stated assumption of more than 10 years for a new nuclear station Grant noted that the environmental assessment alone could take three years and the CNSC licensing process more than two years, before construction could begin.

The document is available on the CNSC website <www.nuclearsafety.ca>

AECL sells ECC strainers to US utility

AECL's emergency core cooling strainer

In late February 2006, Atomic Energy of Canada Limited (AECL) announced that it had been awarded a multi-million dollar contract to design, test and manufacture Emergency Core Cooling (ECC) Strainers for the V.C. Summer nuclear power station, owned and operated by South Carolina Electric & Gas (SCE&G).

ECC strainers are designed for use in emergency situations to filter debris from the water used to maintain the cooling of the reactor core. SCE&G's decision to upgrade the ECC strainer in VC Summer, is in response to a US Nuclear Regulatory Commission's (NRC) Generic Letter requiring assurance that long-term core cooling following a Loss of Coolant Accident (LOCA) will be maintained

The AECL design incorporates porous fins attached to a common header. It is modular and can be sized and configured to fit a wide range of plant layouts and operating conditions. AECL originally developed these finned strainers for use in the AECL-designed CANDU(r) reactors worldwide and has since designed strainers for international utilities who operate pressurized water reactor (PWR) plants.

OPG denies discussing new plants

In mid February, **Pierre Charlebois,** Chief Nuclear Officer for Ontario Power Generation wrote to the Globe and Mail to refute a front page article that stated "OPG had held discussions with the federal regulator about building a new nuclear plant".

Charlebois stated that OPG had indicated to the Canadian Nuclear Safety commission that it intended to proceed with environmental assessment and project scoping for the possible life extension of the units at Pickering B and Darlington.

He added that OPG needs to be aware of requirements that the CNSC may place on such refurbishments and, in that context, how CNSC requirements for new plants might impact the scope of wrok for refurbishment of existing ones.

Cameco completes purchase of Zircatec

At the beginning of February 2006, Cameco Corporation announced today it has completed the acquisition of a 100% interest in Zircatec Precision Industries, Inc. for $108 million. Zircatec's primary business is manufacturing nuclear fuel bundles for sale to companies that generate electricity from CANDU reactors. Ziratec has plants in Port Hope and Cobourg, Ontario.

"With this acquisition, Cameco increases its participation in the nuclear fuel cycle and now covers all phases from uranium mining through to electricity generation," said Jerry Grandey, Cameco's president and CEO.

NB Power and AECL name refurbishment project leaders

New Brunswick Power and Atomic Energy of Canada Limited have named their respective leaders for the refurbishment of the Point Lepreau station.

AECL, which has the contract for the refurbishment, has appointed **David Scott,** general manager of CANDU refurbishment as the Project Director for Point Lepreau.

NB Power has appointed **Rod Eagles** as its Director of Refurbishment, overseeing the project.

Charles (Yung Fen) Chang

Charles (Yung Fen) Chang, a long-term member of Ontario Hydro (now Ontario Power Generation) and a co-winner of the Canadian Nuclear Society's *John S. Hewitt Team Achievement Award,* died February 14, 2006

Charles was born in Shandong, northern China on June 22, 1933. He was the youngest of five sons. From an early age, Yung Fen displayed academic excellence, especially in mathematics and calligraphy. At the age of 14, he was forced to leave home because of the civil war. After traveling half of southern China on foot and by train and ship, he found safe refuge in Taiwan in 1950. During the hardship period he met his future wife, Grace.

Charles graduated from National Taiwan University in 1958 with a Bachelor's Degree in Mechanical Engineering. Following two years in the Navy, he returned to Taiwan University as a teaching assistant for the next three years. In 1963, he received a scholarship to attend graduate studies at University of Saskatchewan.

Charles completed a Doctorate Degree in Mechanical Engineering in 1968. He found employment at Ontario Hydro. During his career with Ontario Hydro Nuclear, he was heavily involved in the development of thermal hydraulic codes, known as SOPHT. In 1998 he was one of the recipients of the CNS John S. Hewitt Team Achievement Award.

He was appointed the technical superintendent in Central Technical Service in Ontario Hydro Nuclear, where he worked until his retirement in 1993.

Charles was diagnosed with Alzheimer Disease in 1995. He passed away peacefully on February 14, 2006, with family at his side.

Chang Yung Fen will be forever missed by his wife Chung Fen; children Lily, Mitchell, Rachel, Richard (son-in-law), and Will; grandchildren Christopher, Alexandra, Michael, Emily, Jonathan and Anthony.

(Prepared by Andrew Lee)

Eugene Critoph

Eugene (Gene) Critoph, one of the leaders of the Canadian nuclear program, died peacefully at the Ottawa Civic Hospital on Friday, February 17th, 2006.

Gene was born in Vancouver, March 29, 1929. After obtaining an M.A.Sc. from the University of British Columbia he joined Atomic Energy of Canada Limited at its Chalk River Laboratories in1953. There he spent several years working in reactor physics and was part of the Nuclear Power Group, that included engineers from utilities and industry, to develop a conceptual design for heavy water moderated power reactor. With Arthur Ward he developed the first code for calculating the reactivity of uranium / heavy water lattices.

Over the years he was Director of Fuels and Materials, Director of Advanced Projects and Reactor Physics, Vice-President of the Chalk River Laboratories and, in 1986, his last posting before retirement, Vice-President of Strategic Technology Management for AECL Research at AECL's Ottawa office. While in that role he sponsored and oversaw the production of the book "Canada Enters the Nuclear Age" to which he also contributed a chapter. Also in 1986, he was awarded the W. B. Lewis Medal, the highest honour of the Canadian Nuclear Association for contribution in science and engineering.

Over the years he represented AECL and/or Canada on a number of international committees, including International Nuclear Fuel Cycle Evaluation (INFCE), the group created by US President Jimmy Carter in 1979 to try to stop reprocessing because of the fears of weapons proliferation.

Gene was predeceased by his wife of 48 years, Beth, who died in 2000. He is survived by four sons and nine grandchildren.

A large number of friends, colleagues, and family gathered at a special reception in Gene's memory in Ottawa on March 5. Among those expressing thoughts was Ralph Green, a long-time associate of Gene's and, like him, a former AECL vice-president. Ralph spoke of Gene's ability as a young physicist to develop "lattice recipes" for the design of nuclear reactors, using just a mechanical calculator. Ralph also recounted Gene's many activities outside of work, with the Deep River Yacht and Tennis Club, star of as Deep River house league basketball, and avid cross-country skier. He also noted Gene's love of, and ability for, puzzles such as cryptic crosswords. Ralph's closing words echoed the thoughts of those in the room when he said, "Gene was an outstanding physicist, keen sportsman, avid puzzler and a great father and grandfather. He will be missed"

Nicholas Martin Ediger

Nicholas Martin "Nick" Ediger, a leader in the Canadian uranium industry, died the day before Christmas, December 24, 2005, in Fredericton, New Brunswick, following an accident.

After graduating in geology from the University of Manitoba, Ediger joined Gulf Oil where he spent two decades until 1973 when he was recruited by the then Minister of Energy, Mines and Resources (now Natural Resources Canada) to become president and CEO of Eldorado Nuclear, the crown-owned uranium mining company.

While with Gulf Minerals Canada Limited, a subsidiary of Gulf Oil, he played a major role in the 1969 discovery and subsequent development of the Rabbit Lake uranium deposit, the first high-grade uranium deposit to be discovered in Saskatchewan's Athabasca Basin. The Rabbit Lake operation, developed jointly by Gulf and Uranerz Canada Limited, was the first to employ a "fly-in, fly-out" program, obviating the need for building a town site. This program required a change in the relevant labour regulations. Ediger was the prime mover in effecting this change in northern mining practice, which is now common practice in Canada's north.

In 1982, as CEO of Eldorado, he was instrumental in the purchase by Eldorado of the Rabbit Lake operation from Gulf and Uranerz, and in 1988, he oversaw the merger of Eldorado with Saskatchewan Mining and Development Corporation (SMDC) to form Cameco Corporation, following governmental decisions to

privatize and merge these crown companies.

He was a founding member of the London-based Uranium Institute (now the World Nuclear Association) and an active Board Member of the Canadian Nuclear Association (CNA). In 1989, shortly after retiring from Cameco he was granted the CNA's Ian McRae Award for his many contributions to the Canadian uranium mining industry.

Ediger moved to Toronto and joined the consulting firm Sentinel Associates. In 1997 he moved to Fredericton and set up the subsidiary Sentinel East. He became a director of two start-up companies and was an active member of the organization Energy Saint John.

He is survived by his wife Beth and daughter Julia.

(With thanks to Dick Williams)

Alan Wyatt

Alan Wyatt, a charter member of the Canadian Nuclear Society, passed away at The Royal Jubilee Hospital Victoria, B.C. on December 29, 2005 at the age of 77 years.

He was born and educated in England. After service in the Royal Navy, he came to Canada in 1957 joining Ontario Hydro as Assistant Project Manager for the Thunder Bay power station. He was then seconded to AECL to develop the steam cycle for a 200 MWe CANDU power unit, and later was appointed Project Thermal Engineer for the Douglas Point nuclear generating station.

He returned to England for a couple of years, working on the construction of pressure vessels. In 1965 he came back to Canada and joined H.G.Acres Ltd., where he worked on studies for AECL and campus planning for Brock and York universities. His next endeavour was as Dean of the Faculty of Arts and Technology at Niagara College from 1967 to 1973, after which he joined Montreal Engineering. Seconded to Canatom as a Senior Consultant, he carried out a number of studies for AECL and assisted in the early stages of the first Wolsong project.

He was appointed Vice-President of Canatom (Ontario Ltd.) in 1975 and established a Canatom office in Toronto. The initial work there was on the design of the Wolsong Service Building. He also provided extensive assistance to the Canadian Nuclear Association at the Porter Commission and Cluff Lake hearings and became Chairman of its Public Affairs Committee. Also, during this period in Toronto, he wrote the following two books, explaining the benefits of nuclear power:

The Nuclear Challenge - Understanding the Debate - 1978 by the Book Press 224 pages.

Electric Power - challenges and choices - 1986 by the Book Press Ltd. 286 pages

In 1987 he produced the first four editions of the Canadian Nuclear Journal published by the Canadian Nuclear Society. His last editorial reported a lack of support to justify the cost of continuing such high quality "peer review" journal.

In addition to having been an active member of several professional engineering societies, he had an MA in Political Science. He was a Charter Member of the CNS, joining in December 1979, and continued his membership after he had retired to Victoria.

(Prepared by Neil Craik)

Robert Lee ("Bob") Clarke

Robert Lee (Bob) Clarke, one of the early physicists at the Chalk River Laboratory, died in Ottawa, December 22, 2005

He was born in Vermilion, Alberta on April 17, 1922 and attended the University of Alberta, where he received the Governor General's Medal upon graduating with a Bachelor of Science in 1943. He worked at the National Research Council from 1943 to 1945 then went to McGill University where he received a Ph.D. in Physics in 1948.

Bob then joined the Physics Branch of the Chalk River Nuclear Laboratories. His research included work with the Van de Graaf accelerator and extensive measurements of activation by, and scattering of, 14 MeV neutrons. In collaboration with a chemist he also organized, and for a time taught at, a Reactor Physics School aimed primarily at students from outside Canada.

In 1968 he joined the Physics Department of Carleton University where he served as Department Chair in the 1970s. Bob introduced medical physics as a new area of research and led the establishment of the medical physics graduate program. He formally retired in 1987 but continued his research on therapeutic ultrasound right up until the month before he died. In addition, he spent many periods of research at the Institute of Cancer Research at the Royal Marsden Hospital in Belmont, Surrey, United Kingdom. In 2005 Carleton named him Distinguished Research Professor.

The medical physics program that Bob inaugurated has prospered. On the occasion of the fifteenth anniversary of the Ottawa Medical Physics Institute in 2004, the Robert Clarke Graduate Scholarship in Medical Physics was set up.

He was a long-time member of the Canadian Association of Physicists, the Canadian Nuclear Society, and the Canadian Organization of Medical Physicists

In 1943 he met Vera Powell at N.R.C. They were colleagues in the Optics Section, and were married in 1945. There are four children, eleven grandchildren and three great grand children.:

Bob Clarke's last scientific conference was in Boston in October 2005. Shortly thereafter, he was diagnosed with advanced cancer. The illness was brief and he died early in the morning of December 22, 2005. A private funeral service was held on December 24. A public memorial was held on Saturday January 14, 2006 at Carleton. Over 180 friends and family were in attendance to honour this remarkable man.

The Robert L. Clarke Graduate Scholarship in Medical Physics

For information please see www.science.carleton.ca/clarke or contact Elizabeth Roscoe, Development & Alumni, Carleton University, 613-520-2600 x8657 or elizabeth_roscoe@carleton.ca

The above note is a slightly edited version of that prepared by Paul Johns, chair, Department of Physics, Carleton University and other friends.

A commentary

CANDU is not an Edsel but it could be an Avro Arrow

by Terry Thompson[1]

Ed. Note: The following is a slightly edited (for length) version of an article based on an address by Dr. Thompson to the Alumni of Mount Allison University in November 2005. He updated some of his references to take into account events subsequent to that address. The views expressed are those of the author.

When I arrived at Mount Allison University 44 years ago, I was haunted by two things: I was told that 1/3 of my engineering class would fail; and an Orenda engine dominated the foyer of the Engineering/Physics building, one of the few remaining remnants of the ill-fated CF-105 Avro Arrow jet fighter in the 1950s.

Thirty months earlier, on 20 February 1959, Conservative Prime Minister John Diefenbaker had announced the cancellation of the CF-105 Avro Arrow, demolishing what Liberal Paul Hellyer characterized as "the greatest single achievement in Canadian aviation history, and the greatest combined effort of design and development ever undertaken in this country".

Some 14,000 skilled employees of A.V. Roe and an estimated 15,000 other skilled tradesmen employed by 2500 subcontractors were discharged that day.

At the time of the cancellation, five fully completed and airworthy Arrows were in existence and, Arrow number 6 was almost ready. Number 6 was the first of the so-called Mark II's, the first Arrow equipped with Orenda's tailor-made Iroquois engine that was expected to take the Arrow to Mach 2.5.

The government had failed to get orders from the United States or Britain and it was deemed uneconomic to develop the Arrow for Canada's use only. Diefenbaker believed the threat had become Soviet missiles rather than bombers, and proposed to rely on U.S. missiles. The bomber threat did not disappear and, two years later, in 1961 Diefenbaker's government acquired supersonic F-101 Voodoos from the United States.

There are many parallels in this story with CANDU: and my message is that with restructured and open electricity markets in Ontario and New Brunswick; international nuclear industry Goliaths are chomping at our heels and the Canadian nuclear industry is in trouble.

First I'd like to address the question of whether CANDU is an Edsel.

In June 2005, Hugh Winsor wrote a column in the Globe and Mail entitled *"CANDU reactor is the Edsel of nuclear power"*. Winsor noted that, while CANDU is a superior technology to the Westinghouse Light Water Reactor, they have become orphans. He noted there are many more Westinghouse-type plants in the world than there are CANDUs. He stated that CANDU is not economic compared to AREVA's 1600MW advanced light water reactor that is already being built in Finland.

Hugh Winsor suggested it was time to kill Canada's dream machine, the CANDU, much as Ford Motor Company killed off its dream car, the Edsel. CANDU is much more than a dream and this is where the analogy with Edsel fails. Out of some 30 trials around the world, CANDU's dreamers succeeded in producing one of only three commercially successful products.

CANDU's designer, Atomic Energy of Canada Limited (AECL), had a relatively small domestic market and a unique technology. It had to do its own R&D and develop its own stable of manufacturers. It survived by being successful in the export market and by having a design that was well suited to the capability of Canadian industry. In addition, it uses natural uranium fuel of a simple design. This makes CANDU attractive to countries with modest industrial capability.

The Canadian nuclear industry did not build an Edsel, a poorly designed product that did not meet market needs. Rather, it built an 'Arrow' that is inherently a better machine from an engineering point of view than the American-type LWRs. As someone once said, the biggest problem with CANDU, is that it wasn't invented in the United States.

Turning back to the analogy of CANDU and the Avro Arrow, CANDU and the Arrow were developed in the post-war period through a public/ private partnership. In the case of CANDU, the [original] partners were AECL, Ontario Hydro and Canadian General Electric. Both developments involved hundreds of millions of dollars of federal government support. In the case of CANDU, it was underlain by an industrial strategy to transfer the technology to smaller, private Canadian companies. This is in stark contrast to the Westinghouse-like Goliaths who do everything themselves.

Unlike the Arrow, some 22 CANDUs have been commercially built in Canada and 11 have been sold abroad. Separately, India has developed a very successful nuclear power program based on CANDU and has 12 units in operation and 6 under construction.

The competition is the three other major nuclear vendors in the world... the three Goliaths... AREVA, General Electric, and Westinghouse:

- AREVA is the government- owned[2] French nuclear conglom-

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1 Dr. Terry Thompson is an independent consultant based in New Brunswick with a particular interest in electric utility restructuring and its impact on the nuclear industry. He is the former regional Vice President for AECL in Asia and a former Managing Officer of NB Power. His current address is: P.O. Box 9060, Shediac, N.B. E4P 8W5 Email thompsot@nb.sympatico.ca

2 Last Fall, the French government cancelled plans to sell shares in AREVA saying the company's business is too strategic to be opened up to investors.

erate that built and operates some 53 plants in France based on U.S. Light Water Reactor technology and was the first to export to China.

- General Electric is the private U.S. giant with a 37% share of the U.S. market, has exported to Japan and Taiwan, and receives massive assistance from the US government.
- Westinghouse is the originator of the type of light water reactor with the largest market share. It is currently owned by a public British company, BNFL.[3]

AECL is in the early development stage of a 1200MW Advanced CANDU Reactor (ACR). It is allowed none of the funding options noted above.

In December 2005, the Ontario Power Authority (OPA), reported on its assessment for a long-term supply mix for generation in Ontario. The OPA report recommended that Ontario maintain its share of nuclear generation at about half the province's needs.

The OPA recommends investigating the refurbishment of existing nuclear units and initiating approvals and permitting for new nuclear of up to 3000MW in addition to replacing the current fleet for a total capacity of up to 15,900 MW by 2025.

Shortly after the OPA report's release, bureaucrats confirmed that not just CANDU would be considered for new build. OPA will likely call for open bids for new nuclear plants. The bidders will be AREVA, GE, Westinghouse and AECL. Each of these vendors will need to partner with an operator.

Bruce Power is a logical partner for AECL but, given the rift caused by AECL's last minute negotiations to wrest Point Lepreau away from Bruce Power, they may well partner with GE.

Bruce Power was expected to refurbish and take over operation of Point Lepreau. New Brunswick restructured its electricity market with the idea that the private sector will provide for new generation. However, publicly-owned AECL was competing for the Lepreau refurbishment job and, at the last minute, improved their offer to the government of New Brunswick. The government deemed the 'insurance premium' required for the private sector to take the risk of refurbishment and operation of Point Lepreau too high; and decided to use AECL as the general contractor, and for NB Power to finance refurbishment and remain in the nuclear operations business.

There is no evidence that the federal government has appetite for the massive new funding required by the Canadian nuclear industry; both for the cost to design and develop an advanced reactor and take the risk of building it. With its mixed CANDU experience, it is unlikely the Ontario government would take the risk of building the First-Of-A-Kind unit again.

In hindsight, one has to conclude that given the political realities of Canada, AECL, with its limited resources, should not have gone down the ACR road; rather it should have put its efforts into standardizing today's designs.

The existing CANDU design is not yet obsolete or uneconomic as projects in Korea and China testify. Canada's nuclear provinces, Ontario, Quebec and New Brunswick can rely on existing CANDU technology to meet Canada's new-build nuclear needs for some time to come.

If the CANDU program is replaced by Light Water Reactors, Canadian funds will be used to the benefit of France or the U.S. rather than Canada.

In this scenario: AECL would continue as a services company only and would support the refurbishment and operation of existing CANDUs over the next 20 or so years, either independently, or more likely owned by a larger [foreign] entity.

Canada's experiment with nuclear power, as brilliant as it was, will be little different than its brilliant experiment with supersonic flight technology.

I am haunted by the failure of the Avro Arrow and fear that CANDU will suffer the same fate.

Canadians were world leaders in supersonic aircraft but gave it away. It is generally agreed, through analysis and subsequent events, that Diefenbaker's February 1959 decision was a major policy error. He received bad intelligence presented in self interest by U.S. defence officials.

CANDU is at risk of suffering the same fate as the Arrow. Now that the Ontario electricity market is open, CANDU will likely have to compete against the French, the Americans and the Japanese in its home market. It will be hard to keep them out.

Hopefully existing CANDU designs will prove competitive in Canada in the near term, and leaders of Canada's nuclear provinces can convince their federal counterparts that, for economic and strategic reasons, it is still the responsibility of the national government to develop new reactor designs, and figure out a new public/private business model to sustain the Canadian nuclear power industry. As the Bruce A refurbishment project showed, no private Canadian entity is big enough to take the construction and market risk alone.[4]

Canada has a huge investment in CANDU- from concept to operation- from building codes to fuelling machines- to thousands of trained people. All of these would have to be 'retooled' if LWRs were introduced.

Most of the information on the Arrow in this article came from two books: Murray Peden's "Fall of an Arrow", first published in 1978, and Palmiro Campagna's "Storms of Controversy" published in 1992. The latter book ends with a question and answer. The answer could equally apply to CANDU.

The question in Campagna's book is "Why was Avro so technically successful with the Arrow"? The author says the answer may be very simple. "They were never told they were not supposed to be able to do it!"

---

3 On 6 February 2006, Toshiba announced it had agreed to buy Westinghouse from BNFL for $5.4 billion, almost three times initial value expectations.

4 The $4.25 billion Bruce A refurbishment project is akin to a new build project. The government of Ontario provided cost overrun guarantees and fixed the base price of power. Even so, Cameco, the world's largest uranium producer opted not to participate in the Bruce A project saying it does not meet its investment criteria. It remains an owner in Bruce B.

More history

History of The Name Canatom

by Neil Craik

Ed. Note: For 38 years, until last year, the name Canatom was prominent in the Canadian nuclear community. After the demise of the name in 2005, Neil Craik, a long-time member of the company, decided that the history of the name should be recorded. Following is a slightly edited version of his report, as part of the Bulletin's on-going "history" series.

Choosing the name

In years of 1966 and 1967, the Canadian General Electric Co. (CGE), of Peterborough was pursuing two possible overseas nuclear power projects; one in Finland and one in Argentina.

Three Montreal consulting companies joined with CGE forming a group called Associated Nuclear Consultants Ltd. (ANCLE). The Montreal consulting engineering companies were:

- SECO - The Shawinigan Engineering Company
- MECO - Montreal Engineering Company
- SNC - Surveyer, Nenniger and Chennevert.

The name ANCLE caused some jokes about the "man from Uncle", a popular but stupid TV show at the time.

The three Montreal consulting firms decided to form an Associate company that would work exclusively in nuclear both overseas and in Canada and which should have a name separate to ANCLE. The first name proposed was Canutech Limited, but to everyone's relief this suggestion was quickly abandoned. The group working on the Atucha, Argentina, bid spent a train trip from Montreal to Peterborough evoking the themes and ideas which were giving birth to the new company - Canada, Uranium, Nuclear, Atomic. The name also had to resonate in both English and French. Before the meeting with CGE, the name **CANATOM** had been selected. Canatom Ltd. was incorporated June 13, 1967.

Projects

Over the years Canatom has worked on nuclear projects in six overseas countries, 12 states in the USA and four provinces, plus various studies and proposals.

The first endeavours were:

- **Atucha** In 1967 the CGE/ Associated Nuclear Consultants Ltd. bid for Atucha 1 in Argentina failed, but provided the first opportunity for the three consulting companies founding Canatom to work closely together.
- **New Zealand** In early 1969 the first contract was a feasibility study on nuclear power in New Zealand, in partnership with Preece, Cardew and Ryder, UK consultants. However, nuclear power did not proceed in New Zealand because of the 1970 discovery of substantial reserves of natural gas.
- **Taiwan** Research Reactor. Later in 1969, AECL who had just signed a contract with Taiwan for a research reactor, awarded the design, construction and project management to Canatom.
- **KANUPP** Over 1972-76 there was a four-year contract with the Pakistan Atomic Energy Commission (PAEC), supported by the Canadian International Development Agency (CIDA), to provide advisory and procurement services. This included: six advisors resident at the Kanupp site near Karachi; supply of a third computer; design of an electrolytic heavy water upgrading plant: and, investigation of a major heavy water loss.
- **Gentilly 2 study**. In September 1972, Hydro Quebec issued a contract for preliminary studies and estimate for a CANDU 6 to be built at Gentilly

The CANDU 6's

It was about 5 years after the formation of Canatom that the company began a relationship with Atomic Energy of Canada Limited (AECL) on a series of CANDU 6 projects. The design responsibility was divided as follows:

AECL:

The Nuclear Steam Supply System (NSSS) including the reactor, moderator and heat transport system and main control room.

Canatom:

The Balance of the Nuclear Plant (BNSP) including the reactor containment building, airlocks and Service Building, plus; the Balance of Plant (BOP) including the turbine building.

On some projects Canatom assisted the owners or overseas engineering companies in the design of the BOP. The exact scope of Canatom's design engineering varied on the different CANDU 6 projects. Canatom staff also provided procurement and resident engineering services..

On some of the overseas CANDU 6's, local engineering companies undertook the detail design and issued the Released for Construction Drawings. This was based on Canatom reference designs and drawings from preceding CANDU '6s, and Canatom staff resident advised the local design engineers.

The title blocks for these RFC drawings did not always include the Canatom name but sometimes there was a note giving the original Canatom reference drawing. In the case of the reactor containment building (RB) for the CANDU 6 at Embalse, Argentina, engineers from TECHINT, Buenos Aires, spent some months in Canatom's offices on design familiarization and developed a RB structural analysis for the specific Embalse site

conditions. The detail design of the RB was then undertaken by TECHINT in their offices in Buenos Aires, under the guidance of the Canatom engineers who were resident there for a few years.

Project start dates

1973 Gentilly 2: BOP and BNSP.

1974 Rio Tercero (Embalse, Cordoba) in Argentina: BNSP.

1974 Point Lepreau in New Brunswick; BNSP and block for the TG.

1976 Wolsong 1 in Korea; CANATOM BNSP and ACRES-CANATOM BOP.

1979 Cernavoda 1 & 2 in Romania; BNSP.

1990 Wolsong 2 followed by Wolsong 3 & 4 in 1992

1996 Qinshan 3 & 4 in China.

In 1975 the subsidiary Canatom (Ontario) Ltd. was formed and an office opened in Toronto. In 1979 Canatom Ltd. changed its name to Canatom Inc.

Canatom in the USA

Over the period 1980 - 1991, Canatom carried out **Prudency Audits** of 15 nuclear power projects in the USA.

In most States in the US, utilities providing a monopoly service to the public were governed by State law that stated that the costs charged for such a service shall only be those costs prudently incurred. In the case of electrical utilities this law meant that only such costs could be included in the rate base used to determine the electrical rates. Electrical utilities routinely submitted their electrical rates for approval to the Public Service Commission (PSC) or the Public Utilities Board (PUB).

Why was the Canatom awarded these Prudency Audit contracts? This goes back to the invitation from the PSC of the State of New York to interested bidders to attend an information session in Albany in 1980. At this session, the PSC stated that they wished to exclude any engineering company with direct or indirect involvement with participants in the Nine Mile Point 2 project, either present or future. That ruled out many knowledgeable nuclear engineering companies in the US. Two staff from Canatom who attended this briefing asked if it would be necessary to be registered as engineers in the State of New York. Later they were approached by US consultants, which resulted in Canatom being included in their successful proposal as sub-consultants. That audit not only facilitated the completion of NMP2, but also led to Canatom participating in Prudency Audits of 15 nuclear power projects in the US. On later projects the partnership with US consulting companies varied.

Following are notes on four of these audits.

Nine Mile Point 2, New York State, 1980. The project had started some years earlier and was advanced in construction, but was then slowed down because of uncertainty in the future demand for electricity. In 1980 the utility determined that the future market for electricity would justify completing the project but wished to ensure that all the costs, including the costs of the delay, would be approved by the PSC for inclusion in the rate base. The assessment was complicated because a number of technical issues had arisen during the project slowdown period. Canatom's client for this Prudency Audit was the PSC of the State of New York. Following completion of that review the PSC retained Canatom in 1981 to monitor construction until the unit 2 went into service in 1987.

Plant Vogtle 2, Georgia, 1987-1988. The privately owned electrical utility, Georgia Power, had built Unit 1. In the case of Unit 2, Georgia Power were again the project managers and majority owners but the agreement with minority owner Ogelthorpe Power stated that only costs prudently incurred would be shared. As the construction costs of Unit 2 increased, Ogelthorpe questioned if all the project costs for Unit 2 had been prudently incurred.

River Bend, Louisiana, 1991. Cajun Electric was a minority owner of Unit 1 but had no share in the ownership of the projected Unit 2, which was not built. Significant preparatory work had been done for Unit 2, and it was questioned how much costs should be charged to Cajun's share of Unit 1, including;

- Some excavation and civil works which appeared to be avoidable if only one unit.
- The cost of the design and engineering costs attributable to Unit 2.

Cajun questioned if any of these costs should be charged against Unit 1 and if all the other costs had been prudently incurred.

Shoreham, New York State. The emergency diesel generator failed during tests causing resulting in costly delays in completion the power station. Canatom's Prudency Audit was on the engineering procurement and testing of the diesel generator at the manufacturers works.

David Besse, Ohio. There had been a feedwater accident which resulted in a long shutdown, and consequent need to refuel the reactor at significant cost. The question was, had the owner/operator's actions been imprudent in causing the feedwater accident and resulting cost of refuelling.

Associated Companies

Over the years Canatom joined with other companies for specific projects, such as the following.

Canatom MHG Heavy Water Ltd. or Canatom Monmax, comprised

- Canatom
- MonMax of Calgary (Monenco, Humphreys and Glasgow of London, England)

These heavy water plant projects were a new technology for Canatom, so this association was formed to undertake the following;

- **Glace Bay.** In 1971 the project of rehabilitation of the existing Glace Bay Heavy Water Plant began. This involved engineering major modifications and commissioning.
- **LaPrade.** In 1974 the design of a new heavy water plant at LaPrade near Gentilly began. The design was completed, a detailed scale model built, equipment ordered and much delivered to site, and the plant about 40% constructed before the project was suspended due to a slowdown in the demand for heavy water.

NCM - Nuclear Construction Managers - A joint venture between:

- Canatom Inc
- Canadian Foundation Company Ltd.

1969, NCM started with the construction management of the Taiwan Research Reactor

1976, NCM had a contract for construction management of Wolsong 1

NPM - Nuclear Project Managers Canada Inc. owned by:

- Foundation Nuclear Mangers Inc
- Monenco AGRA Inc.
- SNC-Lavalin

Provided project construction management, training, NSSS Procurement Services for Wolsong 2 starting in 1990, followed by Wolsong 3&4 in 1992 and Qinshan 3&4 in 1996.

Changes In The Ownership

Over the years the ownership of Canatom changed, as follows.

1967 Canatom Ltd. was formed by SECO, MECO and SNC.

1982 Lavalin purchased Shawinigan Engineering acquiring its third share of Canatom.

1992 AGRA purchased Monenco

1991 SNC and Lavalin merged, giving SNC-Lavalin a major ownership of Canatom

1991 Canatom Inc, owned by SNC-Lavalin and Monenco-Agra Inc.

1999 Canatom NPM Inc, owned by AGRA, SNC-Lavalin and BFC Construction

2002 Canatom NPM Inc owned by SNC- Lavalin and AECON

2005 SNC-Lavalin Nuclear wholly owned by SNC-Lavalin

The Future

SNC Lavalin Nuclear has provided the writer with the following update on the future of [the former] Canatom:

In 2005 the SNC-Lavalin Group acquired full ownership of Canatom, and has embarked on a major expansion of the capabilities and expertise. This ongoing 're-birth' has enabled SNC-Lavalin Nuclear to provide a much broader range of services to the nuclear industry, including Waste Management, refurbishments, and many other projects and services for various nuclear sites.

The company currently is undertaking two major projects at the Bruce nuclear power generating station: The Bruce A Return to Service and the Bruce Units 1& 2 Steam Generator Replacement Projects.

The 'new' company is also embarking on the development of the Pebble Bed Modular Reactor Demonstration Plant in South Africa, which utilizes enriched uranium dioxide fuel encapsulated in graphite spheres to produce nuclear energy.

SNC-Lavalin Nuclear hopes to continue in the tradition of excellence established by Canatom, but offering an even wider array of products and services to the nuclear industry.

About the writer: Neil Craik was recruited from the UK nuclear power program by Shawinigan Engineering in July 1966 and started working on the KANUPP project for the owners PAEC. In 1978 he was appointed Vice-President of Power Projects. Following retirement, he did some part time consulting work for Canatom up to 2004; a 38 year association with the company.

CNS 27th Annual Conference

and embedded CNS-CNA 30th Student Conference

"Nuclear Energy: A World of Service to Humanity"

CNS 2006 SNC
TORONTO

"L'énergie nucléaire: Un monde de services à l'humanité"

27ième Conférence annuelle de la SNC

incorporant la 30ième Conférence étudiante SNC-ANC

Toronto Marriott Eaton Centre Hotel

June 11-14, 2006

It is a time of renewed commitment to nuclear technology, across Canada and around the globe, and a time of increasing public recognition of nuclear energy's service to humanity.

Our 27th Annual Conference will look ahead at new technologies, processes, and solutions being put in place to meet the challenges of building and sustaining a new generation of people and facilities into the long-term future.

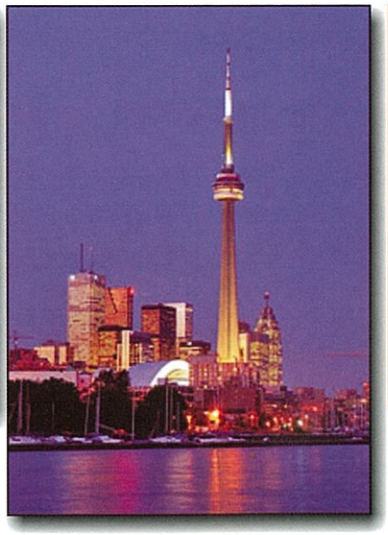
National and international speakers will address many aspects of these challenges, including *long-term security of supply, technical and communication challenges,* and *revitalizing our human resources.*

Presentations in technical sessions will address such topics as *new fuel design programs, advanced reactor designs and new design concepts, thermalhydraulics, reactor physics, control room technology* and *radionuclide supply to the world.*

- *2006 W.B. Lewis Lecture/Luncheon*
- *Three plenary sessions + many technical sessions*
- *Honours & Awards Banquet*
- *North American Young Generation in Nuclear Professional Workshop*
- *Reception, breaks, exhibits, and other networking opportunities*
- *Guest program: breakfast, tours, shopping, etc.*

JOIN US IN JUNE 2006!

For more information and registration, visit www.cns-snc.ca



11-14 juin 2006

Au Canada et autour du globe, un nouveau début s'annonce pour la technologie nucléaire. Et le public se rend compte de plus en plus des services que l'énergie nucléaire a rendus et rend à l'homme.

Notre 27ième Conférence annuelle jettera un regard en avant, sur les nouvelles technologies, les processus, et les solutions nécessaires pour répondre aux défis du développement et du maintien de nouvelles centrales et ressources humaines.

Des conférenciers nationaux et internationaux toucheront sur divers aspects de ces défis, y-inclus *la disponibilité des ressources à long terme, les défis techniques, les défis de communication,* et *le renouvellement de nos ressources humaines.*

Les présentations techniques discuteront de divers sujets, tels *nouveaux designs du combustible, nouveaux concepts de réacteurs avancés, thermohydraulique, physique des réacteurs, technologies de la salle de commande,* et *production de radio-isotopes pour répondre à la demande mondiale.*

- *Conférence/déjeuner W.B. Lewis 2006*
- *Trois sessions plénières + bon nombre de sessions techniques*
- *Banquet des prix canadiens pour contributions nucléaires exceptionnelles*
- *Atelier professionnel de la Jeune Génération Nord-Américaine dans le Nucléaire*
- *Réception, pauses-café, exposition, et autres occasions de développer un réseau de connaissances*
- *Programme pour invités: petits déjeuners, tours, magasinage, etc.*

Soyez des nôtres en 2006 juin!

Pour plus de détails et pour vous inscrire, visitez www.cns-snc.ca

CNS news

CNS comments on OPA report

The Council of the Canadian Nuclear Society decided that the Society should formally comment on the Supply Mix Advice Report issued by the Ontario Power Authority in December 2005. Following is the text of the letter sent to the Minister of Energy, Donna Cansfield on February 6, 2006.

Dear Minister Cansfield,

Re: Comments on Ontario Power Authority Supply Mix Report

As requested, the Canadian Nuclear Society (CNS) offers the following comments on the OPA Advice Report of future energy supply mix in Ontario. The CNS is a not-for-profit professional society of over 1000 members including scientists, engineers, and technical staff dedicated to research in nuclear science and technology, and to the design and construction of CANDU nuclear reactors for electricity production.

The OPA have done a thorough and comprehensive analysis of the present electricity supply situation in the province. The CNS agrees that urgent attention must be paid to replacement of some generating capacity and to increasing the total generating capacity of the province.

Uncertainty is a common factor in all generation forecasts, so that such forecasts need to be robust against major supply uncertainties. The most important uncertainty arises from the fact that natural gas is now in very short supply in Canada and in all of North America. Further, world oil production appears to be past its peak, with large and increasing imports being required from unstable areas of the world. Within the time frame considered by the OPA, shortages of both natural gas and oil with consequent price increases must be expected. Home heating demand probably will shift toward electricity. This shift will increase supply pressure on the electricity sector. The capacity factor of wind-based renewables may be lower than the OPA estimate. Lastly, the introduction of plug-in hybrid vehicles may add to electricity demand during the period. Overall, we expect that more new generating capacity will be required than is projected by OPA.

CANDU technology is ready and able to fill any supply shortage, given the necessary lead time of five or six years between project commitment and in-service. Project costs are well established and competitive. The recently completed Qinshan-3 project in China is offered as a clear example of this capability. That project was finished ahead of time and under budget at a price highly competitive with other Chinese nuclear-reactor projects carried out by French corporations. Based on experience with the Darlington project, it is expected that a new CANDU project in Ontario would be completed with over 90 percent of the project cost spent in Canada, with the majority of expenditures being incurred in Ontario.

Within the context of the OPA report, nuclear energy should be classified as a Renewable Energy Source. This source of energy is inexhaustible, since it is fully capable of supplying the total world energy requirement for thousands of years (D. Lightfoot et al., to be published, Proceedings of the EIC Climate Change Conference, Ottawa, May 2006.).

The OPA report also fails to fully recognize the load following capability of CANDU. Present-day CANDU units are able to load follow for frequency control and during daily load cycles down to 70 percent of full power or less. Future plants will be similarly capable, if the system configuration requires this feature. Nuclear energy could meet daily electricity needs up to about 75% of peak demand, as it already does in France.

Once again we emphasize that CNS members are fully prepared and able to carry out the engineering and project activities to answer the electricity generating needs of the Province of Ontario, now and in the future.

Sincerely yours,
John C. Luxat, President

Branch News

Chalk River - Blair Bromley

The Chalk River Branch will be holding its next public meeting on Wednesday, March 22, 2006 in Deep River in collaboration with the Algonquin Chapter of the PEO. Our guest speaker from Bubble Technologies Inc. (BTI) will be speaking about BTI's R&D in support of Threat Detection. In addition, the Chalk River Branch has also tentatively scheduled meetings on Monday, April 3, and Thursday, May 4, 2006. Our guest speaker in April will be Gregory Smith, Darlington Nuclear, while our guest speaker in May will be Peter Mason, General Electric Canada.

The Chalk River Branch hosted a meeting on January 26, with Dr. Igor Pioro speaking about the Russian Nuclear Power program, and recently a special dinner meeting on February 20, with CNS President John Luxat. John spoke about the energy crisis that North America now faces for supplies of oil and natural gas, and how we must act aggressively to develop nuclear

power, including fast breeder reactors, to ensure our supply of electricity. Both meetings were quite successful, with turnouts of approximately 50 people.

Our schedule for meetings is set for the rest of the spring, and the only other meetings we will be holding will be those in collaboration with the Deep River Science Academy over the months of July and August. We plan to have two or three meetings in the fall, and hopefully one of those will be held outside the Deep River area, possibly in Petawawa, in order to attract members who do not normally come due to travel limitations.

For education and outreach effort, the Chalk River Branch is sponsoring its third annual essay contest on the Applications of Nuclear Science and Technology. Science teachers and principals at all the high schools throughout Renfrew County have been contacted and sent information regarding this contest. We are cautiously optimistic that we will get good participation, and we hope to get at least 10 essays. We may consider advertising in some of the local newspapers. The deadline for submissions is April 30, 2006. The Renfrew County Science Fair will be held on April 1, 2006 at the Petawawa Civic Centre, and the Chalk River Branch will set up a booth there to promote nuclear energy and to help further educate the public. We are also thinking about other ways to promote public education, but we will need more members to volunteer and take responsibility for various projects.

Many thanks are expressed to members Uditha Senaratne, Ragnar Dworschak, Morgan Brown, Marcel Heming, Bryan White, and Jeremy Whitlock for their efforts.

Golden Horseshoe - David Jackson

The Golden Horseshoe Branch is reorganizing (hopefully reinvigorating) the branch executive and I've volunteered to be the Treasurer in order to help out the transition.

Ottawa - Jim Harvie

The first meeting of 2006 was held February 22, with CNS president, John Luxat, as the guest speaker. He addressed the energy situation in North America with a particular focus on security of supply. His topic and a change of venue (to the Army Officers' Mess) attracted a good attendance.

The next meeting is scheduled for March 29 with Bob Pollock of Cameco speaking on the Canadian uranium mining industry.

The Ottawa Branch has again contributed to the Ottawa Regional Science Fair and is offering a prize for a project related to nuclear science or technology. Unfortunately, over the past few years there have been very few, if any, eligible projects.

Saskatchewan - Walter Keyes

Nuclear interest keeps growing in Saskatchewan. With Cameco's stock price going from $16 to $250 in four years, perhaps profitability helps. Uranium exploration is now a $50 million activity. Several Saskatchewan municipal and rural government organizations held a highly successful conference on nuclear development on January 17 and 18. CNS branch helped with organizational matters and provided some publicity. Over 200 'ordinary' people attended the conference. (See Sask branch web site for details.)

Further proposed CNS sponsored speakers include:

- Mar 06 - Regina - Don Ching, President Areva - Luncheon Speaker, Topic: Where Saskatchewan's Uranium Industry is going. Sponsors: Areva and AMEC.
- Mar 06 - Saskatoon - Stan Frost - History of Eldorado. Public Library - Sponsored by CNS.
- May 06 - Saskatoon - CNS Award of Excellence - Getting it Right. - Jeb Tailings System - Dinner. Sponsors: Areva and Golder
- Sept 06 - Saskatoon - Warman's Refinery - Alive and Well in Blind River. Sponsors: United Steelworkers Union - CNS
- Oct 06 Regina - Dinner - Nuclear Power in Canada - Beyond CANDU's - What else is available? Pebble Bed reactors and SNC Lavalin's role in this exciting South African Project. Sponsors: SaskPower - SNC Lavalin

CNS WNU Bursary

The Canadian Nuclear Society will award a bursary of up to $5000 to assist one CNS member who has been accepted to attend WNU Summer Institute 2006: http://www.world-nuclear-university.org/html/summer_institute/index.htm

This bursary is intended to assist with the travel, accommodation and tuition costs for attending WNU. The recipient is responsible for reporting to CNS Council his/her experience at WNU and for providing an expense summary to demonstrate that the funds were applied as intended.

Please note that the **Deadline for Applications for WNU Summer Institute 2006 was 2005 December 5.**

CNS Members in good standing are eligible to apply for this bursary by email to the CNS Office by 2006 May 31.

The application must include:

- information that demonstrates a need for financial support to attend WNU.
- a personal resume and summary of work experience.
- a copy of their acceptance for admission to WNU Summer Institute 2006

The Education and Communications Committee of CNS Council will review the applications received and rank them. The Bursary recipient will be notified by mid-June.

If no suitable recipient is identified, the Bursary will not be awarded.

Education & Communication Committee

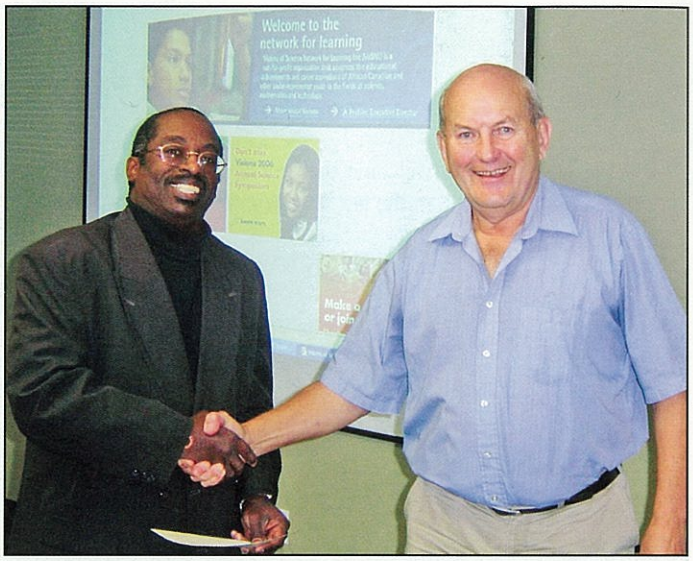
One of the most active committees of the CNS is Education and Communication, headed by Bryan White and Jeremy Whitlock.

As well as the Summer Project and World Nuclear University scholarships (see notices in this issue) they have been and are involved in several other actions. It was they who arranged communication with the Visions of Science group (see photograph) and the ongoing support of the Deep River Science Academay.

The committee is currently pursuing possible CNS participation in the Science Technology Awareness Network, includsng

a CNS exhibit at the Sceince Teachers Associationof Ontario annual meeting next Nvember.

Another project underway is the development of a list of CNS members willing and able to speak publicly. An inquiry sent by e-mail has resulted in almost 50 replies. The committee (primarily Bryan and Jeremy) will be creating a database of those who have responded and are examining the assembly of background materials. They will accept further offers of interest. Their e-mail addresses are: Bryan: <bwhite_cns@sympatico.ca> Jeremy: <whitlockj@aecl.ca> .



CNS vice-president Dan Meneley (R) is shown with Francis Jeffers from the Visions of Science program at the December 8, 2005 meeting of the CNS Council after presenting Jeffers with a cheque for $2,000 in support of the program aimed at encouraging young people of African-Canadian origin to become interested in science and technology.

"Badge-Draw" Winners at CNS CANDU Maintenance Conference 2005

At the end of the 7th International CNS Conference on CANDU Maintenance, on November 22, 2005, 8 prizes were awarded by random draw from among badges returned by Conference attendees.

The winners:

- Warner Anderson, of OPG, won a copy of the book "Unlocking the Atom", by H. Tammemagi and D. Jackson
- Tim Kittel, of Bruce Power, won a CNS sweatshirt
- John Roberts, of Bruce Power, won a CNS golf shirt
- Gordon Burton, of AECL, won a CNS memory stick
- Tracy Gendron, of AECL, won an Inukshuk
- Andrew Justason, of CNER, won an Inukshuk
- Brian Fehrenbach, of AECL, won a complimentary CNS membership for one year
- Gary Zakaib, of OPG, won a complimentary CNS membership for one year.

Congratulations to all the winners!

Gagnants de prix au tirage des porte-insigne à la Conférence sur le Combustible CANDU

À la fin de la 7ième Conférence internationale de la SNC sur l'entretien des centrales CANDU, le 22 novembre 2005, 8 prix ont été tirés au sort parmi les porte-insigne retournés par les participants à la conférence.

Voici les gagnants des prix:

- Warner Anderson, d'OPG, a gagnÈ une copie du livre "Unlocking the Atom", de H. Tammemagi et D. Jackson
- Tim Kittel, de Bruce Power, a gagnÈ un chandail de sport de la SNC
- John Roberts, de Bruce Power, a gagnÈ un chandail de golf de la SNC
- Gordon Burton, de l'EACL, a gagnÈ un b,ton de mÈmoire Èlectronique de poche de la SNC
- Tracy Gendron, de l'EACL, a gagnÈ un Inukshuk
- Andrew Justason, du CNER, a gagnÈ un Inukshuk
- Brian Fehrenbach, de l'EACL, a gagnÈ une adhÈsion gratuite d'un an ‡ la SNC
- Gary Zakaib, de l'EACL, a gagnÈ une adhÈsion gratuite d'un an ‡ la SNC.

Félicitations à tous les gagnants!

New members / Nouveaux membres

We would like to welcome the following new members, who have joined the CNS in the last few months.

Rodney J. Anderson, Environmentalists for Nuclear Energy
Andrea Badcock, Bruce Power
André Brushett, UOIT
Michael Campbell, Black and McDonald Limited
Christopher Canniff, AECL
Joseph Cinelli, AP Services / NGP
Ashlea Colton, UOIT
John Crane, Atlantis Systems International Inc.
Zhenhua Cui, Atlantic Nuclear Services Ltd.
Andrew Day, Atlantis Systems International Inc.
Bill Degnan, Black and McDonald Limited
Tracey Lynn Dobbin, UOIT
Kenneth Ellis, Bruce Power
Abuzar Fariad, UOIT
Brian Fehrenbach, AECL
Allan Freeburn, UOIT
Réjean Luc Gagnon, Royal Military College of Canada
Mike K. Gay
Jamie D. Goodfellow, Babcock & Wilcox Canada
Yevgeny K. Gospodinov, UOIT
Lisa Christine Grande, UOIT
Steve Greenwell, Nova Machine Products
David Grier, Saskatchewan Research Council
Trevor Hall, Atlantis Systems International Inc.
Raheel Hameed, Zircatec Precision Industries Inc.
Vlad Hera, Ontario Power Generation Inc.
Ryan Hewer, Carleton University
Robert Horvath, Babcock & Wilcox Canada
Bahareh Hosseini, OPG
Ming Hu, UOIT
Rashad Hussaini, AECL
Tom Jackson, MDS Nordion
Nitin Raj Jajware, UOIT
Mahmoud Sayed Karam, AECL
Sofiya Kaznady, Ontario Power Generation
Kittima Khumsa-ang, University of New Brunswick
Mike Kisil, UOIT
Janaki Devi Kompella, RELTECH Consulting Private Limited
John Konduros, Atlantis Systems International Inc.
Brad Kyte, OPG

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces derniers mois.

Michael Labriola, UOIT
Witty Lai, UOIT
Nick Lalli, Bruce Power
Corinne Lantaigne, International Safety Research
Jintong Li, AECL
Wenjing Li, Queens University
Cho Su Lim, AECL
Yingxuan Liu, University of Western Ontario
Andrew Lukomski, UOIT
Jianping Ma, University of Western Ontario
Frank MacDougall, Black and McDonald Limited
James (Jim) McCulloch, Bruce Power
Nicholas McKinley, UOIT
Hiren Rashmikant Mehta, University of Toronto
Blake Melnick, Atlantis Systems International Inc.
William Milburn, University of British Columbia
Susan Mokry, UOIT
Sara Mostofian, UOIT
Carmen Neferu, Bruce Power
Gary W. Newman, Bruce Power
Bruce J. Ottenbrite, Ontario Power Generation
Vladimir Ponomarev, Bruce Power
Dominic Rivard, Hydro-Québec, Centrale nucléaire Gentilly 2
Farshad Sani, UOIT
Sumit Sikder, University of Toronto
Marijus Svirskas, Nuclear Safety Solutions Ltd.
Cindy Sypher, RCM Technologies Canada Corp.
Saleh A. Tadros, AECL
Mark Tannous, University of Ontario
Michael Trudeau, Ontario Power Generation
Varaprasad Babu Tummalapalli, University of Manitoba
Alan Tung, UOIT
Richard Van Lochem, Stern Laboratories Inc.
Marius Vartolomei, AECL
Dave White, Black and McDonald Limited
Peter N. Woodward
Polad Zahedi, University of Western Ontario
Ming Zhong, University of Toronto, MIE
Laszlo Zsidai, AECL

North American – Young Generation Nuclear

The CNS/NA-YGN Best Paper Contest

by Brent Williams

The top three papers of the CNS/NA-YGN best paper contest have been identified. The authors have won a trip to Sweden to present their papers at the International Youth Nuclear Congress 18-23 June 2006, as well as one year memberships to the CNS!

The winners are:

Cheryl Cassidy (McMaster University): "Impacts of Low-Dose Gamma-Radiation on Genotoxic Risk in Aquatic Ecosystems"

Bill Scott (University of Ontario Institute of Technology): "Investigation of One-Sided Radiation-Based Approaches to Detection of Visually Obscured Threats"

Dan Quach (Nuclear Safety Solutions): "Application Of Principal Component Analysis In A Nuclear System For Steady-State Identification And Change Detection"

Special thanks to all who took the time to submit papers! The judging was very challenging due to the uniformly high quality of the papers. The IYNC Technical Committee reports that every single entry to the CNS/NA-YGN Contest has been accepted to present to IYNC. Well done!

Very special thanks to the judging team. They reviewed twenty-six abstracts and twelve full papers. They are: Willy Cook, Randal Leavitt, Jeremy Whitlock, and, Ken Yan. When you see them around, thank them for their time and effort.

CNS2006 and IYNC2006 are fast approaching! Make sure you register soon so you won't be disappointed. See you there!

Ed. Note: Abstracts of the three winning papers are printed below.

Impacts of Low-Dose Gamma-Radiation on Genotoxic Risk in Aquatic Ecosystems.

C.L. Cassidy, J.A. Lemon, D.R. Boreham
Department of Medical Physics and Applied Radiation
McMaster University, Hamilton Ontario, Canada

Environmental concerns for potential contamination of ecosystems with radionuclides are important because the effects of low-dose radiation exposures in aquatic species are largely unknown. Research using mammalian model systems has shown that low-dose radiation exposures can alter cellular processes and consequently modify risk from exposure to larger amounts of environmental genotoxins. Therefore, in the nuclear industry, it is critical to understand these effects on aquatic organisms in order to better understand the impacts of low-dose radiation on neighbouring ecosystems. One approach to study these effects is to examine cells that have completed one nuclear division and have DNA damage that has resulted in the formation of a micronucleus (MN). MN are similar in structure and content to the cell's main nucleus but are smaller and may contain either whole rearranged chromosome pieces or fragments of a chromosome and represent genomic damage.

In our preliminary studies, Chinook salmon embryo cells (CHSE-214) have been exposed to various doses of gamma radiation (^{137}Cs source) to establish a dose response curve. Percentage of micronuclei was demonstrated to be proportional to the exposed dose at high doses. However, the cells were relatively resistant at low doses as compared to mammalian cells. At high doses, both human and other mammalian cell lines had many more micronuclei per unit dose compared to Chinook salmon cells. These results demonstrate that the MN assay is a useful cytogenetic biomarker to measure deleterious genomic effects of high dose radiation exposures in Chinook salmon cells. However, at environmental low dose exposure levels the micronucleus assay is not sensitive enough to measure genomic damage directly. Therefore, an indirect approach would be to test the hypothesis that prior low dose exposure at environmental levels will alter the radiation response of these cells to high doses. This will be necessary to understand proper radiation risk assessment of the impacts of nuclear energy production on aquatic organisms. Future experiments conducted on other model systems like Rainbow Trout and Medaka (Japanese rice fish) cells will test the validity of the MN assay for various fish cells. Since fish cells appear to be much more radiation resistant than mammalian cells, we expect that radiation risk in the whole organism may also be lower. Therefore, studies designed to test effects in whole organisms with the specific aim of assessing relative risk between species are in process.

Investigation of One-Sided Radiation-Based Approaches to Detection of Visually Obscured Threats

Bill Scott
University of Ontario Institute of Technology

The limitations of human perception are constantly being improved by technology, as man is fascinated with the abilities he does not possess. One popular interest is in the detection of visually obscured objects. To this effect, a number of different techniques are employed.

One such technique is called Coded Aperture Imaging. What started out, 30 years ago, as a method used by astronomers to image distant stars, is now being used in a very different sense to image near field objects on Earth. The biggest advantage of using coded apertures is that there are no lenses. This means there is an infinite

depth of field and the image does not suffer from chromatic aberration. Without a lens, this apparatus can easily image with sources other than visible light, such as high-energy radiation. When gamma radiation is projected at an object it will produce a detector response, which can be reconstructed to reveal the original object.

Modeling was performed using a specific matrix to generate a mask, which consisted of a three-dimensional geometry of holes for zeros and tungsten for ones. Radiation transport software called MCNPX was used to simulate radiation passing through the holes and registered on the detector. Due to the number of holes, the projection is convoluted, with many copies of the image blurred together. In order to see the image clearly again, digital reconstruction techniques in MATLAB were used. This involved mathematical manipulation in the frequency domain, a technique commonly used in image processing.

Since gamma rays can pass through some materials more easily than others, the images produced will resemble medical x-rays, with shades of grey representing various densities. This will allow the inspection of areas which would otherwise be inaccessible to humans. During the process of maintaining and refurbishing nuclear power plants, there are many situations where this backscatter technology will provide insight otherwise unattainable, in addition to saving time and money. One example would be scanning through concrete walls in search of cracks and fractures in pipes, quickly and efficiently determining whether or not there is need for further action.

The number of applications of this technology is endless, although the urgency of aging nuclear plants stimulates the need for modern methods of inspecting outdated reactor facilities. With the amount of money already required to maintain such facilities, a more efficient inspection technique will limit the reactor's downtime and ease the financial burden.

Application of Principal Component Analysis in a Nuclear System for Steady-state Identification And Change Detection

Dan Quach, Nuclear Safety Solutions Limited

The ability to identify steady-operational time intervals and the detection of changes in operational conditions are non-trivial concepts in the data analysis of complex dynamic systems. Massive amounts of measurements are collected routinely in a nuclear system for extensive periods of time by computers for the purpose of process control. The ability to monitor this data to provide early indication of nuclear plant changes is critical in ensuring stable long term operation with minimal production upsets and for establishing compliance with existing safety analysis parameters.

The analysis using univariate statistical methods (e.g., histograms, averages, etc., using one variable at a time) is both inefficient and often inadequate since a single particular measurement cannot uniquely describe the operational state of a complex process system. In addition, process drift is not always detected by looking at one variable at a time. Rather, a drift in a process condition is often expressed by a group of correlated plant variables.

In this paper, an innovative technique of compressing the information in the multivariate data into lower dimensional sub-spaces where it can be readily analyzed and interpreted will be applied to real operational data. One reliable and efficient method that will be presented is Principal Component Analysis (PCA). PCA's strength lies in its ability to provide an overview of the multivariate data which reveals groups of observations that have smooth time trends (i.e., operationally similar to each other) and groups of data that indicate shifts in process conditions. Furthermore, analysis in multi-dimensional space provides a comprehensive understanding of the complete dynamic system involving all measured variables.

The application of Principal Component Analysis using process measurements from a nuclear system for steady-state identification and change detection will be presented. In addition, the advantages of multivariate analysis for nuclear plant trending over other analytical tools will also be reviewed. These advantages include (but are not limited to) the following: 1) the ability to cope with multicollinearity, 2) the ability to cope with missing data, 3) the ability to handle the very large number of measured variables in a nuclear plant, and 4) the ability to separate regularities from noise.

Expressions of Interest for CNS Bulletin Staff

The Editor of the Canadian Nuclear Society Bulletin, Fred Boyd, has expressed the wish to retire at the end of 2006. CNS Council has established a task force to consider options for ensuring the continuing publication of an interesting and successful Bulletin. The task force is open to a variety of publishing models for the future. The key to success is to have at least a few enthusiastic CNS members involved with the Bulletin. The exact sharing of duties and level of involvement among volunteers and possible publishing professionals is open to discussion. Limited remuneration in the form of honoraria may be offered for key volunteer positions.

Any CNS members who are interested in helping produce the CNS Bulletin are invited to contact the task force. In particular, the task force welcomes discussion with anyone interested in acting as publisher, editor, assistant editor, reporter, photographer, layout person, advertising manager or other role on the Bulletin. These need not be separate positions.

Please let us know your interests.

Contact: Ed Hinchley e-mail: e.hinchley@ieee.org Phone 905 849 8987

'Deadly Sunshine: the History and Fatal Legacy of Radium'

by David Harvie. Tempus, 2005; ISBN 0 7524 3395 4

Reviewed by Don Wiles

This is a most fascinating book. Written for the interested layman, but also of great interest to specialists in chemistry, medicine, quackery and industrial history, this book involves a great deal of intense sleuthing on the part of the author. Starting with the discovery of radiation and the subsequent discovery of the radioactivity of uranium ores and eventually radium, the reader is carried through the difficult work of the Curies into the speculative healing powers and into the widespread furore surrounding the claimed cures of cancer about the time of World War I.

The frenzy generated by this new cure-all led to claims of its curing everything from diabetes, neuritis and schizophrenia to aging and "Debutantes' Fatigue". In turn both industry and Governments sought to protect their sources of uranium ores, and this led to embargos being placed on export of these ores.

At one stage, radium preparations were recommended as farm fertilizers. The activities and claims of the many charlatans could become almost hilariously funny if they didn't verge so close on the tragic. A chapter on the famous dial painters offers an appropriately grim picture, with much detailed information.

I found it initially a bit distracting that the text frequently bounced backward in time to pick up another thread of the story. This, however, was unavoidable, since each chapter dealt with a different version of the history, so that this time-jumping was inevitable. It very soon became evident what was happening, and in fact served well to put the many parts of the story into a context.

Personally, I came into the radium picture quite late (in 1947, as a young chemist recrystallising Radium in Port Hope, Ontario) and by that time most of the serious problems had subsided. Radium burns on my fingers were scarcely noticed until later at M.I.T. where I became a test source of radon in my breath for Prof. Robley Evans. Nonetheless, serious abuse of authority and flagrant ignorance of safety concerns continued, surprisingly, much later than that. The author has read a great many books, reports and newspaper stories. While I didn't check them, those events that I am familiar with rang true.

A number of peripheral topics - the political life of Marie Curie, the development of the atomic bomb, for example - were not included. This is perhaps wise because these topics are well done elsewhere and don't really contribute to the story of Radium.

This is a most interesting and unusual book, dealing with extreme industrial optimism, gross charlatanism, human tragedy and a fascinating interplay between science and the real world of commercial and political ambition. While the subject is occasionally technical, the writing conveys the story very convincingly without recourse to scientifically obscure ideas or terminology. It is to be recommended to all.

The Lost Years

by Jeremy Whitlock

If the present hand-wringing over electricity supply in Ontario seems vaguely familiar, it should: one need only go back one generation.

The year was 1989. Milli Vanilli was still lip-syncing and getting away with it. The Berlin Wall was coming down and Saddam Hussein was about to go from ally to enemy.

In Ontario, with the long saga of Darlington nearing an end, Ontario Hydro released its ambitious 25-year Demand/Supply Plan (DSP), marking the first time that "demand-management" and supply planning were strategically integrated. The study was as doomed as it was groundbreaking: the wind already carried signs of an economic downturn, but nobody suspected that the worst economic storm since the 1930s was about to blow through.

Oblivious to this, and facing 2.2% annual growth in demand with no major new supply in sight, Ontario Hydro set about convincing its customers of the need for 16 GW of new generation by the year 2014, on top of a whopping 6 GW in load-reduction measures.

Then, as now, environmental groups seemed to miss the significance of the conservation measures, and pounced upon the proposed nuclear units like wolves: hungry from years with only the politically mangled carcass of Darlington to feed on.

By 1992 Ontario taxpayers had paid over $23 million in intervenor funding for the Environmental Assessment hearings. The exercise appeared increasingly irrelevant, however, with the economy clearly in the dumper and electricity demand not about to see 2.2% annual growth any time soon.

It didn't matter really, because by now Ontario Hydro was lip-syncing and getting away with it: Bob Rae's NDP government used the recession to cancel new nuclear and fossil planning, double the load-reduction targets, and shore up their gamble with life-extension of existing fossil stations, plus a doubling of the euphemistically-named "non-utility generation" (mostly gas turbines).

Mercifully, little more was squandered on this ideology: the economy continued to tank, the government closed its coffers, planning of all kinds was put on the shelf, and the NDP was booted out (unfortunately not before grafting an ideologue's head onto Hydro's body, in the form of Maurice Strong, who proceeded to ravage the utility with political machinations that made Darlington look like a case study in effective government oversight).

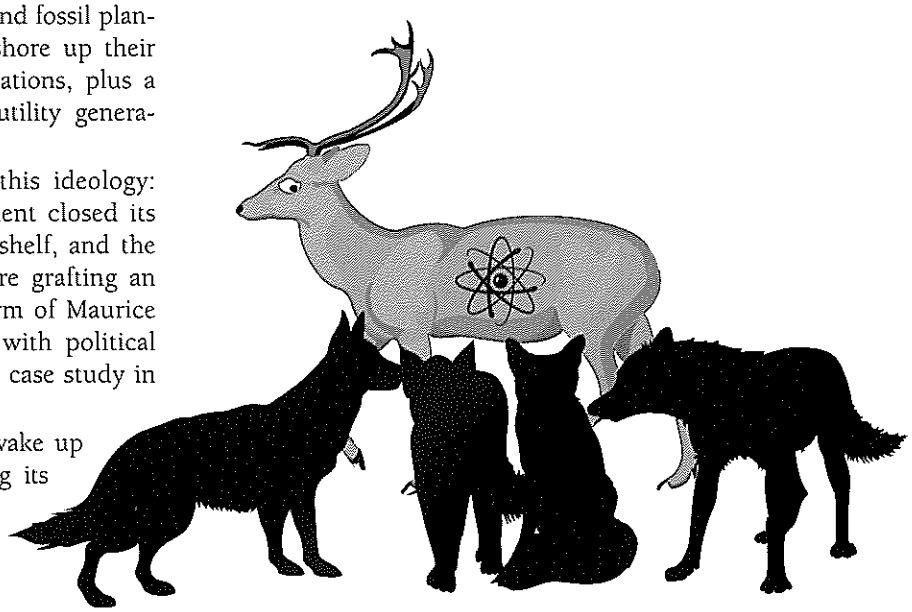
By the mid-nineties the economy started to wake up again, but Ontario Hydro was too busy licking its wounds to notice. Performance waned and a team of Americans was brought in to turn things around. Several millions in salary and pension later, most of the Americans were gone and seven reactors were shut down prematurely. The utility no longer had the strength to even lick its wounds - at least not all at once.

That brings us to 2006. Ever so quietly, without much fuss, the economy of Ontario has been inching upward, and electricity demand along with it. The once-capable planning department of the former Ontario Hydro is no more, but lo and behold: today's provincial peak electricity demand of 26 GW is roughly what they said it would be at this time back in 1992 (albeit now a summer air-conditioning rather than a mid-January heating peak).

What's more, there's little new about recent predictions of a 30 GW load in Ontario by 2014: it was all there in the 1992 update to the DSP. What's new is the political decision to not meet this load with coal stations, a cart suggested by some to be distinctly ahead of its horse.

It is hard to imagine why crisis management should ever be a part of electricity supply planning. Indeed, if one looks back 35 years at the record of Ontario peak demand, it increases at a steady average rate of about 400 MW per year. Even after the late 1980s, when energy consumption decoupled itself from the GDP, peak demand (the main determinant of load-meeting capacity) continued to track GDP pretty well. There are no surprises here, except those artificially imposed.

Moreover, on this basis, one wonders if the currently proposed supply mix to 2025 in Ontario is not a little heavy on renewables (8 GW) and optimistic on demand management (2 GW). One hopes, of course, that there is no lip-syncing again going on, although it's hard not to note that the song sounds oddly the same.



CALENDAR

2006

Apr. 3, 4 — **CWESI-2**
2nd Canadian Workshop on Engineering Structural Integrity
Toronto, Ontario
contact: CNS office

Apr. 27, 28 — **PLIM + PLEX 2006**
Paris, France
website: www.neimagazine.com/plex

May 9 - 11 — **CRPA Annual Meeting**
Toronto, Ontario
website: www.CRPA-ACRP.ca

May 9 - 12 — **EIC Climate Change Conference 2006**
Ottawa, Ontario
website: www.ccc2006.ca

May 31 - June 2 — **WIN Global**
Cambridge, Ontario
Contact: Susan Brissette, Bruce Power
email: susan.brissette@brucepower.com

June 4 - 8 — **ANS Annual Meeting & ICAPP 2006**
Reno, Nevada
website: www.ans.org

June 11 - 14 — **27th CNS Annual Conference & 30th CNS/CNA Student Conference**
Toronto, Ontario
website: www.cns-snc.ca

Sept. 10 - 14 — **Physor - 2006 Physics of Reactors 2006 Advances in Nuclear Analysis and Simulation**
Vancouver, British Columbia
website: www.cns-snc.ca/physor2006
email: physor2006@aecl.ca

Oct. 15 - 20 — **15th Pacific Basin Nuclear Conference**
Sydney, Australia
website: www.pbnc2006.com
email: pbnc2006@tourhosts.com.au

Nov. 12 - 16 — **ANS Winter Meeting**
Albuquerque, New Mexico
website: www.ans.org

Nov. 26 - 29 — **5th CNS International Steam Generator Conference**
Toronto, Ontario
website: www.cns-snc.ca

CNS Membership Renewal Reminder

If you have not yet renewed your CNS membership for 2006, but would like to retain your membership in good standing, please take a moment to do it now. Please return the individual membership renewal form which you received in November, or fill out and return the renewal form available on the CNS website at www.cns-snc.ca. **Non-renewed memberships will be definitely cancelled in mid March.**

Thank you.

Ben Rouben

Chair, Membership Committee

Rappel de renouvellement d'adhésion à la SNC

Si vous n'avez pas encore renouvelé votre adhésion à la SNC pour 2006, mais aimeriez garder les bénéfices de votre adhésion, veuillez prendre un petit moment pour le faire tout de suite. Veuillez renvoyer le formulaire individuel que vous avez reçu en novembre, ou bien remplir le formulaire disponible sur le site internet de la SNC, à www.cns-snc.ca. **Les adhésions non renouvelées seront définitivement annulées à la mi-mars.**

Merci bien.

Ben Rouben

président du comité d'adhésion

CNS Scholarship for undergraduate summer project

The Canadian Nuclear Society is offering a scholarship to promote nuclear science and engineering in Canadian universities. This scholarship is designed to support undergraduate summer work projects in nuclear science and engineering at Canadian universities.

Two awards of $5000 are available for the summer of 2006.

Each award will be to an undergraduate student for a specific summer work project related to nuclear science and engineering.

Requirements:

- There must be a faculty member supervising the project who is a CNS member in good standing
- The supervisor must provide an additional $1500.
- The student must be enrolled in an undergraduate degree program, and must not be completing the program in the winter-spring term of 2006.
- The project duration must be at least three months.

Awards will be based on the academic standing of the student and the merit of the proposed project. An independent panel, appointed by the CNS, will review submissions and make award decisions.

Applications

Application must be sent by e-mail to:

Dr. Eleodor Nichita
University of Ontario Institute of Technology,
School of Energy, Systems and Nuclear Science
e-mail: eleodor.nichita@uoit.ca

Submission deadline: March 31, 2006
All applicants will be informed of Awards on April 21, 2006
Payment: May 15, 2006

For further details go tot he CNS website <www.cns-snc.ca>

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CNS WEB Page - Site internet de la SNC

For information on CNS activities and other links – Pour toutes informations sur les activités de la SNC

http://www.cns-snc.ca

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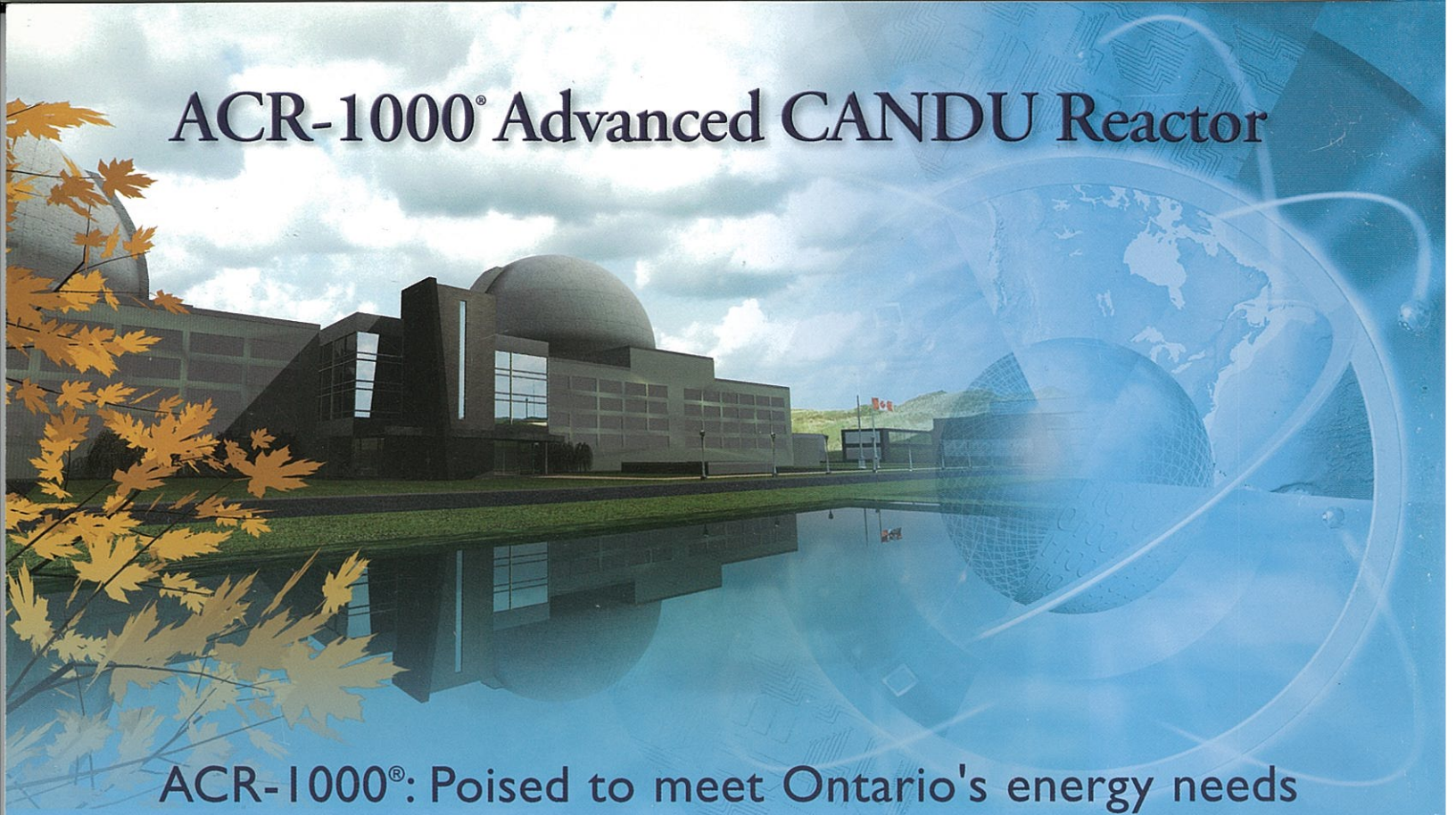
ACR-1000® Advanced CANDU Reactor



ACR-1000®: Poised to meet Ontario's energy needs

- The ACR-1000 reactor builds on the CANDU 6 experience to deliver improved safety margins as well as lower capital and operating costs. It also provides for ease of maintenance and excellent operating performance with high availability, improved passive safety, extended plant life and fast construction.
- Designed for the world market, the Canadian made ACR-1000 is a world-class, Generation III+ reactor that is poised to meet Ontario's energy needs, by enhancing the advantages of the CANDU design.
- The ACR-1000 represents global technology that will allow Ontario to be an export leader in nuclear energy.

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